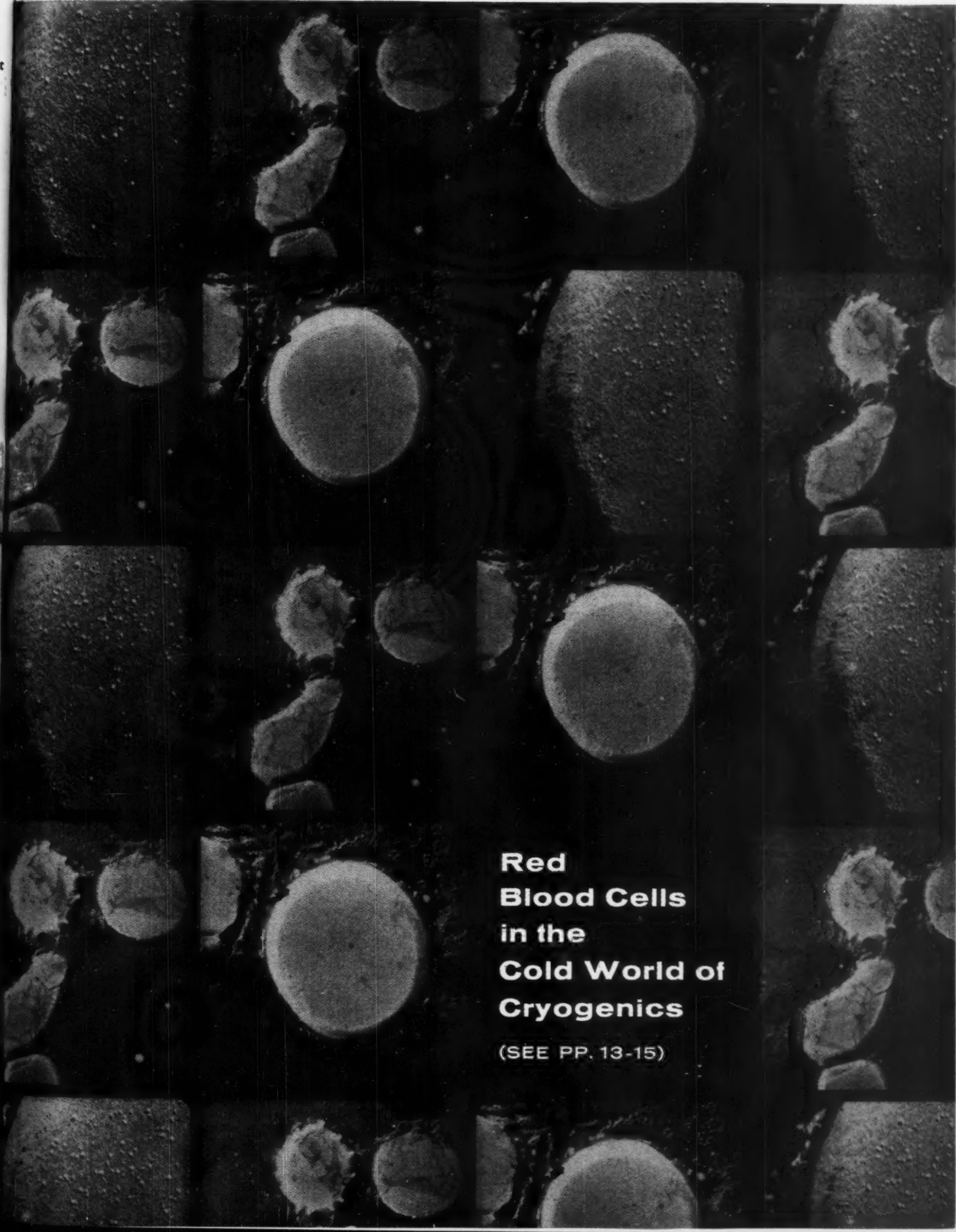
SCIENCE WORLD

VEMBER 4, 1959 • VOLUME 6 • NUMBER 5 • A SCHOLASTIC MAGAZINE



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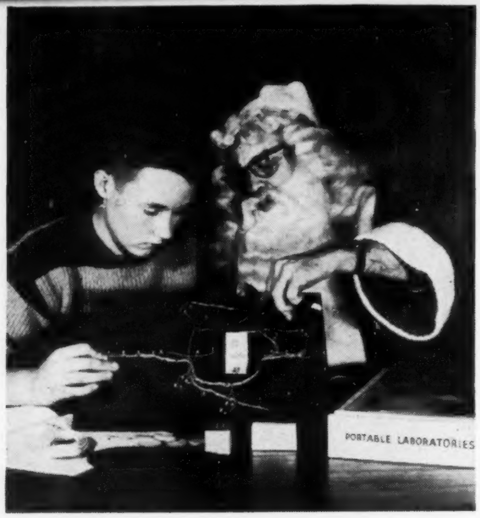
(SEE PP. 13-15)



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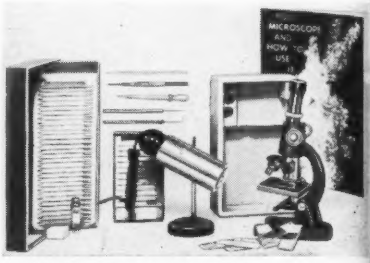

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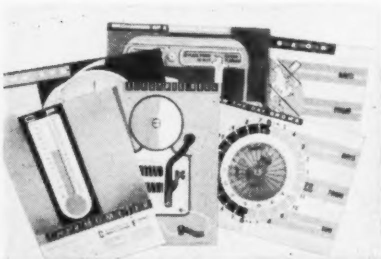

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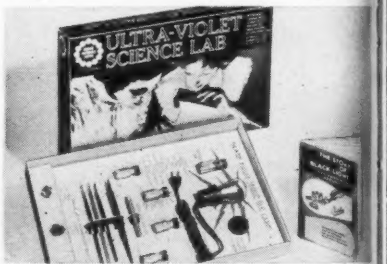

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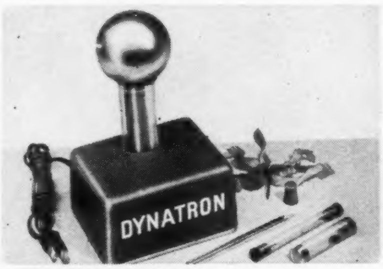

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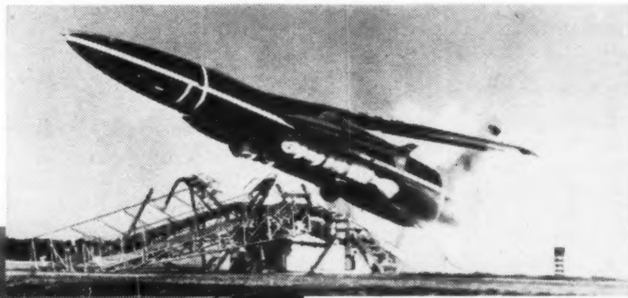

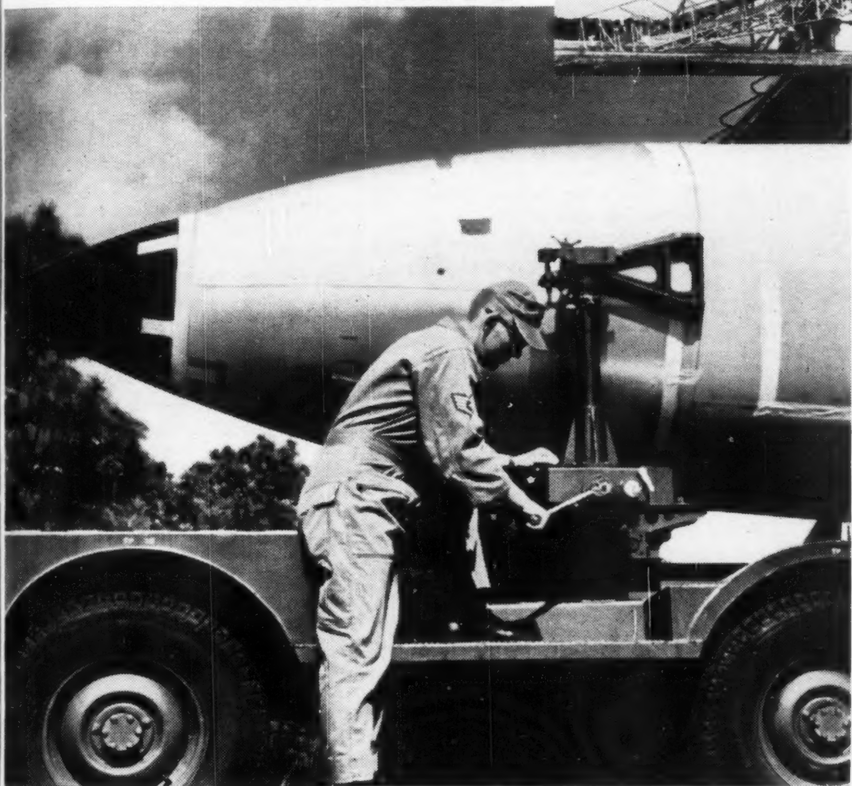

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Letters

In the September 9 issue of *Science World*, we asked readers to answer this question from D. J. Alan McIlroy, a student in Scotland: "Is space infinite? If not, how does it end?" We received scores of replies. Here are some of the most interesting:

Einstein and Curved Space

Einstein implies in his theory of relativity that the universe has a very definite shape. The reason its limits cannot be seen is that, like the Earth's surface, space itself is curved and has no definite boundaries as we would know them. Thus a light ray from a star is not given off to be lost in space, but must return to its starting point. This is the same as the traveler on Earth who starts on one part of the Earth and keeps going until eventually he ends up at the place where he started.

Einstein said that the universe is increasing in size all the time. The galaxies that are far away seem to be moving farther away from the sun, so that it seems that the whole universe is expanding.

The big question is: If the universe has a definite shape and dimension and is expanding, what is on the other side of it, and what is it expanding into? If there is *nothing* on the other side, our universe is infinite. If there is *something*, then it is finite. But since space in itself is nothing, it is hard to say where we can draw the line. How can we ever arrive at a definite point and say that it is the end of space?

What is not conceivable to the imagination may be conceivable to mathematics. Maybe some day a special kind of mathematics will be invented to solve this problem.

Mark Fuehrer
7608 Aldrich Avenue
Minneapolis, Minn.

Balloon and Simple Deduction

Among theories on the universe . . . there is one very familiar one. It is known as the "theory of the expanding universe." It states that the universe was first formed from a gigantic explosion, which sent matter streaming out in all directions from a central point. This seems to be upheld because of the fact that the stars and the galaxies are known to be receding from each other at tremendous speeds.

Try to visualize a toy balloon being inflated. At first the sides are very close together, but as the balloon is inflated, the sides spread out and separate from each other. Two points (representing stars) on the sides get farther away from each other. If this is the case in the universe, then there has to be an end, or better, an edge to it. You can see that by using the balloon and simple deduction. . . .

David Dunlap
LaFeria High School
LaFeria, Texas

[How about a good working definition of space—as used in "man's exploration of space"?—*Editors*]

Mt. Palomar photo

Giant nebula in Andromeda is like galaxy or universe of stars in which our sun and planets exist. This great star system measures 120,000 light years across.

Infinite and Expanding

The consensus among scientists seems to favor the theory that the universe is expanding and is infinite.

In 1929 the astronomer Edwin Hubble stated that the universe was expanding. His evidence included unique photographs of distant star systems and a definite red shift in the spectrums of these systems.

A red shift seems to indicate that a star or galaxy is moving away from our planet, although this theory is still debated among astronomers. Hubble, and others who followed him, believed that the farther the star systems moved away from our telescopes, the farther the light that formed their spectrums had to travel. Therefore, there was a decided shift to the red end of the spectrum because the longer light waves traveled toward that particular section.

Since Hubble's discovery, radio astronomers and astronomers working with the 200-inch reflector telescope at Mt. Palomar Observatory have confirmed his theory. Some galaxies are moving away from each other at speeds of 38,000 miles a second.

Myron Ginsberg
185 Centre Street
Brockton, Mass.

Senses Define Limits

My definition of the word "space" is everything outside of the Earth that man is able to see and discover, such as the stars and the galaxies. Now if we are willing to accept this definition, then it becomes quite obvious that space, as taken here, is not infinite, as our senses are quite limited.

However, I think that there is another term that should be defined—universe. My definition of the word "universe" is *everything* that exists, whether observable to us or not. Therefore, it becomes equally obvious that the universe, of which "space" is but a minute part, is infinite.

As to the other question, how does space end, I wouldn't really attempt a guess, as I've never been out to its boundaries (if there are any definable boundaries) to see.

Alice Kempe
258 22nd St., N. W.
Barberton, Ohio

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C O N T E N T S

Features

Departments

Science in Quotes

You must be familiar with the very groundwork of science before you try to climb the heights.... Perfect as the wing of a bird may be, it will never enable the bird to fly if unsupported by the air. Facts are the air of science. Without them the man of science can never rise. Without them your theories are vain surmises. But while you are studying, observing, experimenting, do not remain content with the surface of things. Do not become a mere recorder of facts, but try to penetrate the mystery of their origin. Seek obstinately for the laws that govern them. And then—modesty. Never think you know it all.... Retain the courage to say, "I am ignorant." Never be proud. —IVAN PAVLOV

The cars are safer . . . the roads are safer . . .

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You're getting plenty of help to make driving safe. Automotive designers have made today's cars the safest ever built. Excellent visibility, improved brakes, easier steering, stronger tires and better lighting are among *their* contributions. And let's not forget the traffic experts who help build safety into driving. They give us expressways, underpasses, divided highways, clearly marked directions and warnings. But these automotive and traffic experts need help from *you* in return . . . and it's easy for you to give. Just practice courtesy, alertness, caution, respect for the rights of others. This makes driving safer, more fun, and means that you will enjoy the opportunity and privilege of driving more often.

GENERAL MOTORS A CAR IS A BIG RESPONSIBILITY—SO HANDLE WITH CARE!

Catch a Falling Star

By ELIOT TOZER

Ten months of preparation and the hopes of 500 men went into a 24-second experiment

THE scientists and engineers at the Army Ballistic Missile Agency (ABMA) in Huntsville, Ala., were in trouble.

Under Dr. Wernher von Braun, they had learned how to build and fire the Jupiter, an intermediate range ballistic missile (IRBM). They knew how it performed in the early moments of its tremendous arcing flight into space. They had photographed and studied a dozen launchings with cameras and instruments from the blockhouse. But the Jupiter's performance at the pay-off end —during its plunge toward earth— was still a tantalizing unknown.

Small wonder.

The Jupiter slams into the top of the atmosphere at 15,000 mph. Friction with the air sublimates the nose cone—causes the cone's metal surface to pass from a solid to a gaseous state. The resulting clouds of ionized gas interfere with the transmission of data by the missile's instruments to down-range trackers.

Seconds later, the cone plows into the ocean at almost the speed of sound—even when slowed by recovery parachutes. The instruments are often shattered, their recordings smashed to unreadability.

After several urgent conferences, ABMA's scientists determined to conduct a daringly new experiment: a close-up study of the cone's re-entry into the atmosphere—at the point of impact.

To some, the idea seemed preposterous. With missiles as erratic as Fourth-of-July roman candles, they said, how would the experimenters know where to set up their instruments. To get good pictures, the cameramen would have to be within a few miles of the impact point.

Other doubters said it would be almost impossible to find the tiny six-foot-diameter cone high in the night sky, and focus on it in the few seconds it took the cone to plunge 67 miles through the atmosphere into the ocean—especially from the slippery deck of a bucking destroyer.

And there was always the chance —perhaps only one in a million, but a chance, nevertheless—that the cone would scream down onto one of the ships.

All photos from Barnes Engineering Company

Glowing like a ball of incandescent gas, rocket body of Jupiter IRBM re-enters Earth's atmosphere. Photo was made 7.62 seconds after rocket was first sighted. Body is followed by glowing instrument package, and preceded by the nose cone.

But in August 1957 a small task force of Navy ships and Army aircraft had found a Jupiter nose cone less than an hour after it had plummeted into the shark-infested waters off Antigua in the Caribbean. Perhaps crews of instrument specialists could set up their gear in the ships and aircraft of the next recovery task force, and sail in close enough to get usable data.

Purpose of Experiment

Under young Dr. David Woodbridge, a physicist from Seattle, staffers at ABMA's Research Projects Laboratory agreed that they would study (1) the upper atmosphere; (2) the fiery sublimation of the cone; and (3) the effects of the hypersonic plunge—about five times the speed of sound—on the cone itself.

The data would be of great value not only to the engineers who design our missiles, but also to those who hope to set up a defense against enemy missiles.

A civilian contractor, Barnes Engineering Co., had been a member of the scientific team studying the behavior of missiles at launching. Their specialty was measuring the radiations coming from missiles during flight. Dr. Woodbridge and his group determined to do the same: "measure and analyze the infrared, visible, and ultraviolet radiation emitted by the cone during re-entry."

They dubbed their project Operation Gaslight.

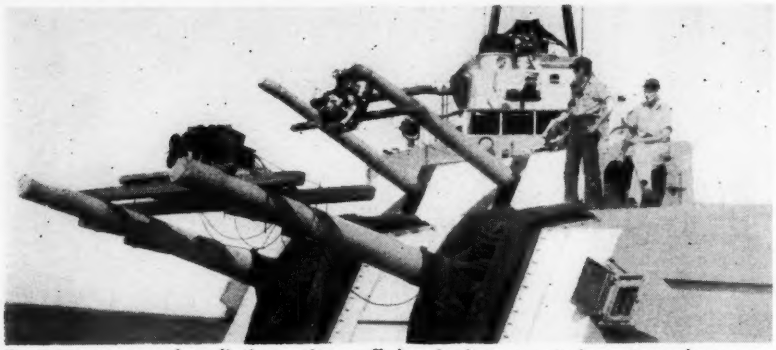
Infrared, visible light, and ultraviolet radiation are, of course, waves of electromagnetic radiation. They differ in wave length (distance from peak to peak) and frequency (number of vibrations per second).

Infrared rays have the longest wave length: from about 0.75 microns to 1,000 microns (a micron is equal to 1/10,000 cm).

Visible light is next longest: from about 0.3 to 0.7 microns.

And ultraviolet runs from 0.01 microns to 0.4 microns.

Scientists know a good deal about the kinds of radiations different atoms produce under various conditions. Each kind of radiation is caused by atoms in a different state of motion. Therefore, by studying the nose cone's radiation, scientists



Cameras to record radiations given off by Jupiter re-entering atmosphere are mounted on rear guns of *Stickell*, to make use of destroyer's tracking system.

could discover which atoms emitted it, and what was happening to those atoms at the time.

Dr. Woodbridge knew that the success of Operation Gaslight depended on having exceedingly sensitive instruments. We can easily measure the radiation from a hot iron in a dark laundry room. But a missile nose cone whizzing toward us from outer space at 15,000 mph presents special problems.

The scientists knew that the scientific principles behind their instruments were just as valid in space as they were in a laundry room. But the instruments had to be designed with great accuracy for precise measurements. The scientists needed sensitive cameras to photograph the spectrum of visible and ultraviolet radiation, and sensitive radiometers (instruments designed to measure the intensity of radiant energy) to record infrared radiation.

Choosing the Team

In October 1957 the Russians shot Sputnik I into orbit. The word went out: "Get going!" Into Dr. Woodbridge's office at Huntsville, Alabama, came urgent orders to be prepared to make readings on the next scheduled Jupiter, only six months away.

It seemed an almost hopeless task, but with the help of Mr. Ray Hembree, a physicist from Acworth, Georgia, Dr. Woodbridge began talking things over with specialists who could contribute most to the unusual experiment. Out of the conferences evolved a scientific "team" and the play-by-play teamwork that is characteristic of modern scientists and engineers at work.

From the Geophysics Research Directorate (GRD) of the Air Force Cambridge Research Center came young Richard Ellis, graduate of the Massachusetts Institute of Technology. GRD studies the structure and behavior of the whole universe—the air, earth, and water—for the Air Force. Ellis and GRD's other physicists cheered when they were asked to participate. Operation Gaslight would give them their first chance to analyze a re-entry body of known size, weight, shape, composition, velocity, and trajectory. The body would appear at a specified time in a specified place. It would be a rare opportunity to conduct a controlled re-entry experiment.

GRD agreed to supply a special Speed Graphic camera that would break down visible radiation as a prism does; photoelectric radiometers that would measure and record infrared radiation; a motion picture camera for documentary photography.

Dr. Woodbridge also invited engineers of the Avionics Division of Aerojet-General Corp., specialists in the manufacture of infrared equipment for controlling guns, guiding missiles, and "seeing" through darkness. Robert L. Howard, a Nevadan, said Aerojet-General would be happy to participate because Operation Gaslight would give them a chance to compare the actual performance of their equipment with their theoretical hopes.

Dr. Arthur Kantrowitz, graduate of Columbia University and director of Avco Research Laboratory, accepted Woodbridge's invitation quickly. He "saw an opportunity to check predictions based on our research with our shock tube (a high-speed, high-temperature wind tunnel)." Avco would provide a star camera to pinpoint the cone's position.

Harold Yates, a young graduate of Johns Hopkins, represented Barnes Engineering Co., makers of radiometers that measure infrared radiation. Barnes specially developed an instrument for Gaslight. This used mirrors to focus infrared radiation on a thermistor—a tiny flake of rare metallic oxide. When the rays strike this thermistor, its resistance changes. If it is hooked into an electrical circuit, any changes in infrared radiation change the circuit's voltage output.

Barnes agreed to supply other equipment, including a tape recorder to capture the excited comments of the engineers as the cone hurtled toward them. It was an inspired addition to Gaslight's gear. Seldom has tape captured more awe-struck words than those of the hard-bitten engineers watching their first re-entry of a missile.

Task Force Gathers

By late in 1957 the tension was mounting. Dr. Woodbridge called several conferences to make sure each company knew what the others were contributing. He flew to Norfolk to request a destroyer and tugs for the 50-odd scientists and their tons of equipment. He went to Washington to ask the Army for three huge four-engine C-54 transports to carry additional scientists and even more equipment. Then he flew to the Air Force Missile Test Center (Cape Canaveral) to set up the complex telegraph-and-radio system that would link his ships and aircraft with the engineers in the Canaveral blockhouse.

Trouble dogged him. The missile "took sick" and the launching date was edged back two weeks, six weeks—no telling how long. And as the days of early spring grew longer, each tropical storm became a potential killer. Hurricanes are common in the North Atlantic in May.

By May 13, 1958, all Gaslight personnel had gathered at the U. S. Naval Base at San Juan, Puerto Rico. There they had hastily stashed their gear aboard the USS *Stickell*, the *Swordknot*, two destroyer escorts, and a Navy tug. By noon the tiny task force was steaming east

by south toward Antigua in the Caribbean, with rumors buzzing that the Jupiter would blast off on May 17. Feverishly, they ripped open the cases and drew out the cameras, radiometers, and other equipment that they hoped would record the story of the missile's final plunge and tell what happened to the nose cone.

"It's Off!"

Harold Yates of Barnes elected to mount his spectral camera on the *Stickell*'s rear guns so he could track the blazing missile with the guns' sighting gear. Avco mounted its camera on two other guns in the same turret. It was an ingenious idea—but it didn't work. The vibration of the mechanisms that compensate for the pitch and roll of the ship ruined the tracings of the instruments. The scientists stabilized their cameras with the guns' manual system instead.

By May 17 the task force had drawn into a 30-mile circle northeast of Antigua. Most gear was in place. The tension was electric. Although the sea was calm—"State One," said *Stickell*'s navigator—the sky was clabbering up. With hours to go, cirro-stratus veiled the sky thinly, and puffy cumulus clouds were boiling up in the northwest.

Exhausted, their nerves raw, the 15 scientists on the *Stickell* catnapped on deck. It was too hot to go below—almost 90 degrees with 83 per cent humidity. And they knew they couldn't sleep. By midnight or shortly after, they would hear the long tone on the telegraph that would signal "blast off!"

Every man-jack on every ship and all the bird-dogs in the C-54s orbiting lazily overhead knew that the missile would take off on a trajectory of 111 degrees. It would probably first appear at an elevation of 45 degrees under the star Arcturus, and race across the heavens under Spica. Commander R. G. Brown, skipper of *Stickell*, ordered a heading of 290 degrees to intercept it and a speed of 10 knots to cut the ship's roll.

Then, in the darkness, the word flew throughout Operation Gaslight. "They're counting!"

The crews touched once more the banks of switches on the consoles of their gear, studied once again the winking lights that said, "All O.K.," and crossed their fingers. Ten months of preparation, thousands of dollars worth of equipment, and the hopes of almost 500 men in a circle of ships and planes on the lonely Atlantic were about to be paid off.

The tension grew. A quiet five-knot breeze riffled the paper on a clipboard and men jumped. Crew chiefs issued their orders in tight, low tones.

Suddenly Yates cried, "It's off!"

At 1:16 a.m. on May 18, 1958, the Jupiter roared upward off her pad at Canaveral and leaned over into the trajectory that would carry her 1,500 miles toward the men of Operation Gaslight.

A thousand eyes stared northwestward, but Commander R. G. Brown, veteran of night battles in the Pacific, was the first to find it. At almost exactly the spot predicted, the Jupiter blinked into view like a dim star. The cumulus clouds had moved south, and now in the midst of the excited cries almost everyone saw it.

Hoarsely, someone yelled, "Did you start the timer?"

"Yes, yes," came the reply.

24 Awesome Seconds

Overhead, the arcing Jupiter seemed to break into two parts—a huge ball of incandescent gas that was the rocket body, and a smaller star just behind it, the instrument package, glowing an intense blue-green. The body glowed fitfully. Long streamers of molten material flowed along her flanks and trailed off into nothingness.

Suddenly, in front of the body, a small orange-red dot appeared. It burned steadily, smoothly. And, as suddenly, went out. It was the nose cone. Slowed by the atmosphere and the sudden opening of parachutes, it had cooled quickly below the level of incandescence.

But the body and the instrument package hurtled on, both now pulsing like giant balls of burning magnesium. In the last few seconds they shot behind a cloud and the whole cloud lit up. As they roared into view again, they lit up the entire task force and the ocean for miles around. It was an awesome spectacle.

Within 24 seconds it was over.

Quickly, Commander Brown called for 28 knots and the *Stickell* raced to the impact point, directed by the excited C-54s overhead. Down into the warm, dark water slipped the Navy frogmen. An hour later the cone, streaked and burned, was resting in a special cradle on the deck of the Navy's *Escape*.

Since May 1958, the scientists of GRD, Avco, Aerojet-General, and Barnes have been poring over the thousands of feet of data they recorded in those momentous 24 seconds. By correlating motion pictures, still pictures, and a careful analysis of the Jupiter's nose cone, they were able to learn much of value to the designers of missiles and missile defense systems.

What they learned can't be told yet. But from the final conference on Operation Gaslight, held at Huntsville just last week, will surely come the knowledge men need not only to "catch a falling star," but to comprehend the stars that don't fall.

Nose cone, recovered by Navy frogmen, is being loaded into protective container.

By MICHAEL BLOW

F. M. Demarest photo

Since 1920, U. S. Fish and Wildlife Service has kept record of all birds banded.

U. S. Fish and Wildlife Service photo

Band on goose gives clue to bird's travels. About one in ten banded birds is found again.

Science World graphic

Arctic tern makes longest migration, an annual trip of about 25,000 miles—from the Arctic to Antarctic and back again.

Tracking Down the Migrants

Scientists are unraveling clues that may solve the mystery of why some species migrate

EACH year at this time, countless numbers of birds, fish, insects, and animals are on their way to winter quarters – and, in another hemisphere, to summer quarters.

Some of them will relocate a short distance away, others many thousands of miles. The Arctic tern is off on a 12,000-mile flight southeastward across the Atlantic and then down the coast of Africa to winter in the Antarctic. Chimney swifts are on their way from Nova Scotia to Brazil.

Eel larvae are leaving the sluggish waters of the Atlantic's Sargasso Sea. Those on the western edge of the sea are caught up in eddies that carry them westward on a long meandering voyage to the rivers of the United States. The larvae on the eastern edge are swept toward Europe by the waters of the Gulf Stream.

All over the world these vast migrations are being closely watched by naturalists and biologists. In Cutch, India, for example, ornithologists and virologists of the World Health Organization of the United Nations are trapping and banding birds from the great flocks which swarm into India for the winter from Central Asia. The reason: The birds are suspected of carrying the virus responsible for recent outbreaks in India of a form of encephalitis found in the Soviet Union.

And once again scientists are pondering two questions they have only begun to answer: What extraordinary urge impels these mass migrations? And what are the spectacularly sensitive senses by which these animals manage to navigate to the precise spot they or their ancestors left the previous spring?

For these are no ordinary hit-or-miss trips. Many species travel thousands of miles to reach the same nest, pool, or cave that they left six months before.

These two questions have been baffling mankind for thousands of years. As late as the Middle Ages some men firmly believed that swallows hibernated in the mud of ponds, that cuckoos changed into hawks in the winter, and that some birds flew up to the moon in the fall.

It was not until the twentieth century that scientists began to penetrate the mysteries of migration.

Biologists now know, for example, that during the spring glandular changes take place in many of the

migrators. As the days grow longer, the reproductive organs in birds become larger (this effect can be produced artificially in winter by using light bulbs to simulate the sun), and the birds grow nervous and restless. There also seems to be some activation of the thyroid and pituitary glands. Scientists are not sure which of these glands triggers the spring migration of birds—or even whether they do.

How Migration Began

Biologists studying eels, fish, and mammals have found a similar type of glandular activity at the time of migration. The young salmon's wanderlust comes over him along with a surge in glandular secretion, apparently attributable to the thyroid. And the same thing occurs in the furry mouse-like lemmings. A wild excitement ensues, and most (but not all) of the lemmings leave their tunnel homes in the Arctic to begin a long journey towards the sea. This eventually turns into a mass "suicide" by drowning.

This glandular change does not occur in all species, of course. Even when it does, it doesn't force all birds and animals in that species to migrate. For instance, some Illinois robins migrate to New Orleans in the winter, but others stay at home, inhabiting the same nests both winter and summer.

Scientists have no clear understanding of how migration originated, but they do have some tentative theories.

The simplest theory is that many species migrate to find a more comfortable climate and a more adequate food supply. If this is the case, however, then why do some bluejays, robins, and hawks take a winter vacation in the south, while others set up winter quarters in their northern nests? Even more difficult to understand is the assumption that the migrating animals know world geography well enough to "plan" their travels.

Why, in fact, do birds migrate at all? Most of them are admirably well adapted, with their feathery coats and warm blooded nature, to endure winter climates. Indeed, many spend the winter in the frozen Arctic, hunkered down in the snow during the storms.

In many cases, moreover, birds leave their summer homes long before the food supply is exhausted and the cold sets in. On the other hand, birds often fly north too soon, arriving in their summer grounds so early that they perish in a spring cold snap.

How, then, did the migrating habit originate?

One theory holds that with the last ice age many birds were forced to move south to survive. Thousands of years later, as the glaciers retreated, the descendents of these birds, endowed with an inborn memory of their ancestral home, worked their way back to the old nesting grounds.

Another theory assumes that all birds once inhabited the southern hemisphere. As the bird population increased and the food supply grew short, some of the birds were forced north in the spring to find less congested breeding areas. They returned in the fall.

Whatever originally caused the migrating instinct, it now seems to be hereditary. And so is the remarkable navigational ability that goes with it. Scientists have artificially hatched the eggs of migrating birds and kept the fledglings caged until all the others of their species had taken wing to the south. When released, the young birds unerringly flew to winter nests thousands of miles away.

But birds are by no means the only great navigators among the migrants. Many kinds of fish and whales navigate accurately over vast distances. Bees seem to have a built-in inertial navigation system, such as that used in ballistic missiles. Even the blind, water dwelling horseshoe crab can find its way up the beach at spawning time.

How do they do it?

Finding the Way Back

In many cases scientists are still at the hypothesis stage. For example, scientists know that the eel larvae spawned in the Sargasso Sea are carried to Europe by the Gulf Stream. But no one knows how the mature eels find their way back over thousands of miles of ocean to produce the next generation.

Some icthyologists now think that eels are equipped with some sort of rudimentary sun compass which enables them to tell direction. But even this assumption fails to explain how they can navigate in the dark depths of the sea at night. Perhaps the discovery by oceanographers of a great river of water flowing underneath the Gulf Stream and in the opposite direction may help to provide an answer.

The homing instinct of salmon is just as remarkable. Two years after being born in a fresh water stream, the salmon winds its way downstream to the open sea. Two years later it returns to fresh water to spawn, usually in the same little stream or creek where it was born.

The Scent Trail

One of the most awe-inspiring experiments involving salmon is being done at a laboratory on the campus of the University of Washington at Seattle. A sluice way was built many years ago to allow salmon spawned in the laboratory to go to sea. Several years later, as adults, these salmon came swimming into the laboratory to spawn.

Biologists think that a sense of "smell" enables the salmon to sniff out dissolved organic substances in the water which the salmon remembers from its early days. In most cases fish seem to have a far more developed olfactory sense than man. The theory has been checked by plugging the nostrils of salmon on their way home. They were unable to find their birthplace.

This theory may explain how the salmon can detect its home stream, and perhaps even the river it flows into. But the theory fails to explain how the salmon, which is known to travel hundreds of miles from the river mouth, finds its way back.

The rest of the animal kingdom gives us many similar examples, most of them largely unexplained. Cats, mice, dogs, whales, seals—and even ants and crabs—all seem to be able to find their way home from considerable distances.

But of all the animals that navigate, birds are probably the most remarkable. Recently, scientists have begun to understand how birds navigate,

For a long time it has been known that birds have a sense of time, just as man does. In man this sense is

apparently buried in the subconscious. Under hynotism, people have obeyed instructions to the minute without looking at clocks.

In birds the interior "clock" chimes more clearly, and it is much more accurate. It tells them, for one thing, exactly *when* to migrate. Many species arrive in their summer and winter quarters on exactly the same date each year. For another thing, it enables them to calculate distances. If birds are following landmarks—and some birds making short migrations do—then they can probably calculate by dead reckoning the distance flown in a day.

Even this remarkable ability, assuming it exists, does not fully explain the incredible voyages made by certain birds at night and over water.

For instance, a shearwater was trapped on Skogholm in the British Isles and transported to Boston. Released there, the bird homed in on Skogholm 12 days later, beating the letter bearing the news of its release. There are hundreds of similar examples.

Bird Navigation

A number of theories have been advanced to explain these flights:

- The bird has a built in "compass" and can align itself with the lines of force of the Earth's magnetic field;
- Like certain missiles, the bird is sensitive to heat and has an infrared detection system that enables it to see through darkness;
- It is able to detect the air movements resulting from the Earth's rotation and thereupon align itself in the right direction.

Scientists feel that none of these theories is supported by sufficient evidence. More recently, however, it has been suggested that birds nâvigate, just as man does, by both the sun and the stars.

Scientists have suspected for some time that birds can steer by the sun, as do some other members of the animal kingdom. Ants, for example, do an about-face when the sun is blocked off and they receive its reflection from a mirror on the opposite side. Certain crabs, insects, and perhaps some fish, also depend upon the sun for their sense of direction.

P. J Huizen photo from U. S. Fish and Wildlife Service

Lesser Snow Geese breed in the Arctic regions and winter on the Gulf Coast, in California, and in Mexico. Migrating geese fly high enough to escape detection.

But what of those birds, such as the European warbler, which migrate only by night? Are these birds capable of celestial navigation?

Apparently they are. The mechanism of the inner "computing system" which enables some birds to navigate—without the complicated instruments man uses to "shoot the stars"—is still unknown. But the experiments of Dr. E. G. F. Sauer, a German ornithologist, show that some birds apparently have such a mechanism.

Sauer took European warblers, which migrate southwest from northern Europe to Egypt, then south down the Nile to central Africa, and placed them in a glass-topped cage. At the time the birds would normally leave their summer home for Africa, the birds seemed to peer anxiously at the night sky and then point southwest.

When their perches were rotated, the birds stubbornly turned back to the preferred direction. When the night was cloudy the birds became completely confused. They were unable to point.

Sauer then put a warbler named Johnny, who had never made the trip to Africa, in a blacked-out planetarium. Without stars, the bird was again unable to find the correct heading. But as soon as Sauer illuminated the planetarium dome with the fall night sky over Europe, Johnny immediately pointed southwest.

Sauer then shifted the stars on the dome so that they indicated the geographical location of Vienna, nearly north of Johnny's African nesting grounds. Without hesitation the bird pointed due south.

Further experiments confirmed that Johnny was getting his bearings by celestial navigation. The little bird, which had never even made the flight to Africa, was showing an inborn ability to use the stars to guide him on his first trip to winter quarters in Africa.

Sauer is now at work removing constellations from his planetarium sky one by one, to see whether he can find the specific pattern of stars used by the bird.

If Sauer ever does find out how the birds do it, no one will be happier to learn the secret than the U. S. Naval personnel on Midway Island in the Pacific.

The Mystery Remains

Long plagued by thousands of albatrosses, which make aircraft landing at Midway a hazard, the Navy tried some experiments in relocation. In one of them, 24 albatrosses were banded and carted off by the U. S. Fish and Wildlife Service to the far corners of the Pacific. The rest of the albatrosses were to follow if the experiment worked.

Six birds were taken to Japan, and six each to the Philippines, Alaska, and the State of Washington. The result: Within two months 20 of the big "stupid" birds returned to the tiny island in the middle of the Pacific, after winging distances of up to 5,000 miles.

How did the birds do it? Scientists are seeking the answer.

Amidst the glamor of moon-circling satellites and all the other scientific successes of our time, a "Johnny" warbler can still keep alive man's ability to wonder.

By SIMON DRESNER

Scientists and engineers are hot on a cold trail that leads them to absolute zero

The Cold World of Cryogenics

A COUPLE of years ago, some scientists performed a remarkable experiment. It would have made the best parlor magicians envious. They slowly lowered a metal ball over the center of a metal ring. As the ball descended, it seemed to become lighter and lighter. Suddenly it stopped descending and remained floating above the ring—without any visible support.

According to the scientists, the ball could float there forever.

This might seem like the perfect "sky hook." But it is only one of the many unusual phenomena that can take place in the super-cold world of *cryogenics* (from the Greek *Kryos,* meaning icy cold). This is the area of science that deals with temperatures near absolute zero—minus 459.6 degrees F., or minus 273 degrees C.

The experiment demonstrated the phenomenon of superconductivity. This is a characteristic of certain metals when they are cooled to a few degrees above absolute zero. At those temperatures the metals lose all resistance to electrical flow and become "superconductors." They conduct electricity without any loss in electrical energy.

Zero Resistance

To understand how superconductors made possible the experiment we have described, we must go back 50 years to the work of a Dutch physicist, H. K. Omnes. He passed an electric current through frozen mercury and made a startling discovery. He found that at a few degrees above absolute zero, all resistance to the flow of current ceased. The interesting thing about this experiment was not that the resistance ceased—but that it ceased while the mercury was still several degrees above absolute zero. This contradicted theories of electrical resistance that were widely accepted by scientists at that time.

We know that electrical current in a metal is transmitted by the motion of electrons. The electrons collide with atoms. The motion of the atoms impedes the flow of electrons and results in electrical resistance in the metal. As temperature drops, the motion of the atoms decreases, and the metal should present less resistance to electron flow. Therefore, according to theory, the metal should show zero resistance only at absolute zero—where atoms are practically motionless.

No one has yet fully explained why resistance should vanish abruptly while the metal is still several degrees *above* absolute zero. The most promising explanation is that at very low temperatures, the motion of the atoms is synchronized (in time) with the motion of the electrons. Resistance to the flow of electrons disappears.

Whatever the full explanation may be, the fact of superconductivity remains. It was dramatically demonstrated a decade ago by inducing a 40 ampere electrical current in a superconductive lead ring—a current which circulated in the ring for two and a half years with no detectable change or loss of energy. The ring was immersed in liquid helium to cool it below its transition point (the point at which it becomes superconductive), a few degrees above absolute zero.

General Electric photo

Low temperature studies are being conducted in General Electric lab. Cryogenics is used to develop improved computers and special amplifiers for radar.

Researchers ended the experiment when they were convinced that superconductivity really meant perfect conduction—or zero resistance.

A later discovery showed still another peculiar property of metals in a superconducting state—they repelled a magnetic field. The explanation was simply this: The magnetic field would build up so-called "persistent currents" in the metal (as in the lead ring). These currents would then create an identical *opposing* magnetic field.

By now it should be easy to guess the explanation of the experiment described in the opening paragraph.

Ball and Ring—Explained

Both the ball and ring are cooled to the point where they became superconductive. A "persistent current" is set up in the ring, creating a magnetic field around the ring. As the ball is lowered, the magnetic field in the ring induces a "persistent current" in the ball. In turn, the current in the ball produces its own magnetic field, directly repelling that of the ring—just as like poles of bar magnets repel each other in a laboratory demonstration. Result: The ball floats above the ring. Theoretically, it could float forever, since the "persistent currents" will last as long as the metals remain superconductive.

This phenomenon is being explored by scientists and engineers. It might be applied to develop frictionless bearings in a high vacuum.

One of the first thoughts that came to cryogenic researchers was that they could now make "super"-electromagnets, "super"-motors, and "super"-generators. The wire used would be superconductive, yielding 100 per cent efficiency. This might mean, for example, making a power house generator the size of a fan motor.

The reseachers were in for a disappointment. Another interesting property of superconductors made this impossible: A magnetic field could bring a superconductor back to normal resistance, no matter how cold it was.

But scientists turned this liability into an asset. They designed an electrical switch around this phenomenon. This switch, called the Cryotron, is half the size of a pin. It is ideal for computers, which may use millions of such switches.

The Cryotron is simply one wire coiled around another wire, both superconductive. Usually, one wire is made of tantalum, the other of niobium. When one wire has a current flowing through it, a magnetic field is set up around the other wire, changing the other wire back to normal resistance. Thus one wire can halt the flow of current in another wire—in effect, acting as a switch.

Using these tiny switches, a computer that is now the size of a room could be crammed into a few cubic feet. The entire equipment would be immersed in liquid helium to keep it at superconductive temperatures.

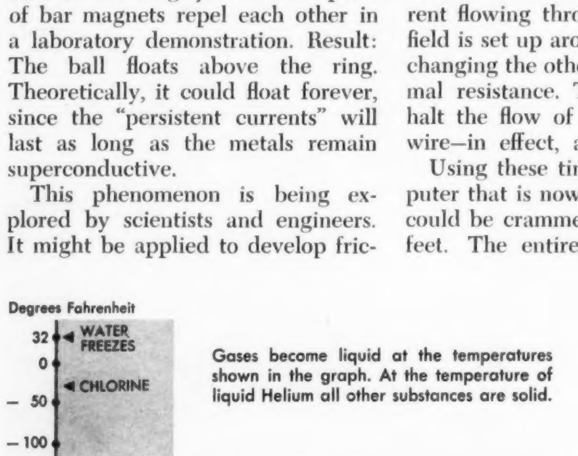
Just as some metals can become superconductive, some liquids may become "superfluids" at cryogenic temperatures, exhibiting unusual properties. One of these is the phenomenon known as "creep." Liquid helium, for example, tends to creep up and over the walls of its container, eventually emptying itself from the container completely. Liquid helium is also a superconductor of heat. Heat waves flow through liquid helium just as sound waves travel through water—a property that has been named "second sound."

Record Temperatures

Many other unusual phenomena take place at cryogenic temperatures. Carbon dioxide, which we know as a gas, becomes solid at about minus 75 degrees C., and turns into the familiar "dry ice." Oxygen and nitrogen become liquid at much lower temperatures, less than 100 degrees Kelvin (in the Kelvin scale, zero degree is absolute zero, −273 degrees Centigrade). It is there that the true world of cryogenics begins.

At even lower temperatures, a few tenths of a degree above absolute zero, oxygen and nitrogen change from liquids into solids, resembling white snow.

Cold, as we know it on Earth, is far above these temperatures. The



Gases become liquid at the temperatures shown in the graph. At the temperature of liquid Helium all other substances are solid.

The colored section shows the temperature range in which certain metals become superconductive, carrying electricity with little or no resistance.

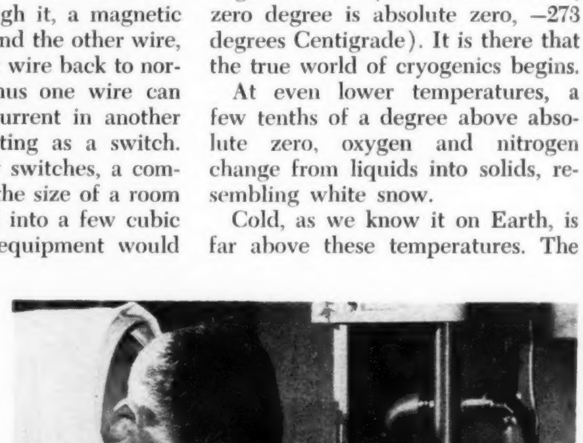


Photo from Linde Co., Div. of Union Carbide

Lab equipment above is used to study effects of freezing on red blood cells. Microscope "cold cell" uses liquid nitrogen. It is equipped to take photos for permanent records.

coldest temperature ever recorded on the surface of the Earth (outside the laboratory) was 102.1 degrees below zero F. in the Antarctic. This was recorded on an alcohol thermometer. The usual mercury thermometer would have been frozen solid at only 30 degrees F. below zero.

In the outer reaches of space, however, temperatures may approach absolute zero. This would present a serious obstacle to scientists working on space problems. Some materials, such as carbon steel, become very brittle at low temperatures. Space vehicles may have to be constructed of non-ferrous metals such as aluminum or copper. These retain most of their strength at low temperatures without becoming brittle.

The lowest temperature ever recorded was achieved in the laboratory two years ago. It came close to absolute zero—20 microdegrees Kelvin, or twenty millionths of a degree above absolute zero. It's not hard to guess that this was not reached by using an ordinary refrigerator.

Cooling with Magnets

Low temperatures are usually produced by a liquefied gas—often helium. The temperatures which can be achieved, however, are limited by the boiling point of helium, which can be reduced to a minimum of about one degree Kelvin. To reach even lower temperatures, cooling must be done magnetically, by a process called *adiabatic demagnetization*. (The word "adiabatic" refers to changes in matter that take place without transfer of heat.)

By this process certain salts can be cooled to extremely low temperatures. In practice, a salt is first cooled to one degree Kelvin by immersing it in liquid helium. Then a magnetic field is turned on which lines up the ions in the salt, giving off heat in the process and raising the temperature. The heat is absorbed by the helium, and the salt returns to one degree Kelvin. Then the salt is insulated from the helium, and the magnetic field shut off. The ions go back out of alignment, withdrawing energy (and heat) from the salt crystals. The result is a marked cooling effect.

When this process was carried out in several steps with various substances, the record low temperature of 20 microdegrees was achieved.

Liquid helium's low boiling point makes it the most important gas in cryogenic experiments. Unlike liquid hydrogen, it is non-explosive and safe to handle. Because of this, there has been a great deal of interest recently in conserving the world's supply of helium.

Helium is never found in nature combined with other elements. Although it is present in the air in small quantities, the cost of extracting large quantities from liquid air would be prohibitive.

How We Measure Cold

Most of the helium used today comes from "helium wells." These are natural gas wells which also have a high percentage of helium. The United States is the only country in the world which has these helium wells. Many of these wells were being tapped for natural gas rather than helium. Billions of cubic feet of helium thus were being lost annually. Government officials recognized this problem. Today most helium is extracted from natural gas by the Government and stored in Government facilities.

There is one important problem in cryogenics which you should have been wondering about by now—how are such very low temperatures measured? Temperatures must be measured to a fraction of a degree with great accuracy, in a range where molecular motion, which is related to temperature, is practically non-existent. Obviously, the thermometers we are familiar with simply won't do.

One method is to use the thermocouple—two dissimilar metals joined at one end. A difference in temperature between the joined and unjoined ends creates a small electrical potential. This potential can be used as a measure of temperature.

For example, a copper-constantan thermocouple yields about 17 microvolts per degree centigrade at the boiling point of oxygen (90 degrees Kelvin). However, at really low temperatures the thermocouple becomes ineffective. The power output approaches zero as the temperature approaches absolute zero.

Massachusetts Institute of Technology photo

Cryotron held by Dudley Buck (now deceased) was developed by him in 1957. In super-cold, two tiny wires can act as switch, replace vacuum tube in computers and other electronic equipment.

Another method uses the fact that the resistance of a wire is proportional to its temperature. A platimum wire, therefore, can be made to serve as a thermometer at low temperatures, simply by measuring its resistance. Similarly, some semiconductor materials, such as germanium, show measurable electrical characteristics at low temperatures.

For extremely low temperatures, below 1 degree Kelvin, the only measuring device that works is the magnetic thermometer. This uses the known properties of certain salts at very low temperatures.

Measuring extremely low temperatures becomes almost as difficult as reaching them in the first place.

The science of cryogenics is relatively young. Low temperature research is being conducted at more than 100 laboratories across the nation. Researchers are enthusiastic about the commercial application of low temperature phenomena. Scientists and engineers are developing ways of producing heavy water—composed of oxygen, and hydrogen atoms that contain a proton and a neutron—through distilling hydrogen at low temperatures. This could be used in commercial atomic power plants. One third of the cost of such a plant goes for heavy water moderators.

And some day the bearings in your car—cooled by liquid nitrogen—may outlive the rest of the car.

Science in the news

Russian Photos Show a "Two-Faced Moon"

The Russian rocket camera recently gave astromomers their first look at the "far side" of the moon. The photos taken by the camera didn't settle any arguments. Instead, they created a host of new ones—about the structure and origins of Earth's nearest neighbor.

The photos did satisfy one aspect of scientific curiosity—the far side of the moon has a smoother surface than the side seen from the Earth. The moon seems to show a different face to the rest of the universe than it does to its Earthbound observers.

The photos showed an absence of craters and seas on the moon's far side, revealing it to be much more monotonous than the rugged terrain facing the Earth. Evidence of a "two-faced" moon supports a theory which had predicted the moon's far side would be relatively smooth.

According to this theory, the lunar "seas" resulted from the tug of Earth's gravity when the moon was molten. (The "seas" are believed to be black deserts of lava or dust, which give the "man in the moon" his features.) Because of this tug, the side of the moon facing the Earth bulges nearly one mile in that direction.

This bulge has been described as "a frozen tide," held permanently in the grip of Earth's gravity. The stresses and strains of its creation may have built up some of the lunar mountains and seas on the Earth's side, leaving the opposite side smoother.

One astronomer has suggested that the difference between the two lunar faces could have resulted from a shower of meteorites striking the Earth's side of the moon.

Before the theories can be confirmed, scientists will need more revealing photos. The Russian photos were taken with the sun directly over the area photographed, thus eliminating shadows. Photos made with the sunlight at an angle to the moon's surface would show strong shadows, revealing much greater detail about the terrain. Similarly, telescopic photographs of a full moon taken from the Earth show a smoother lunar surface than photos taken during an earlier or later phase, when the sun is low in the lunar sky.

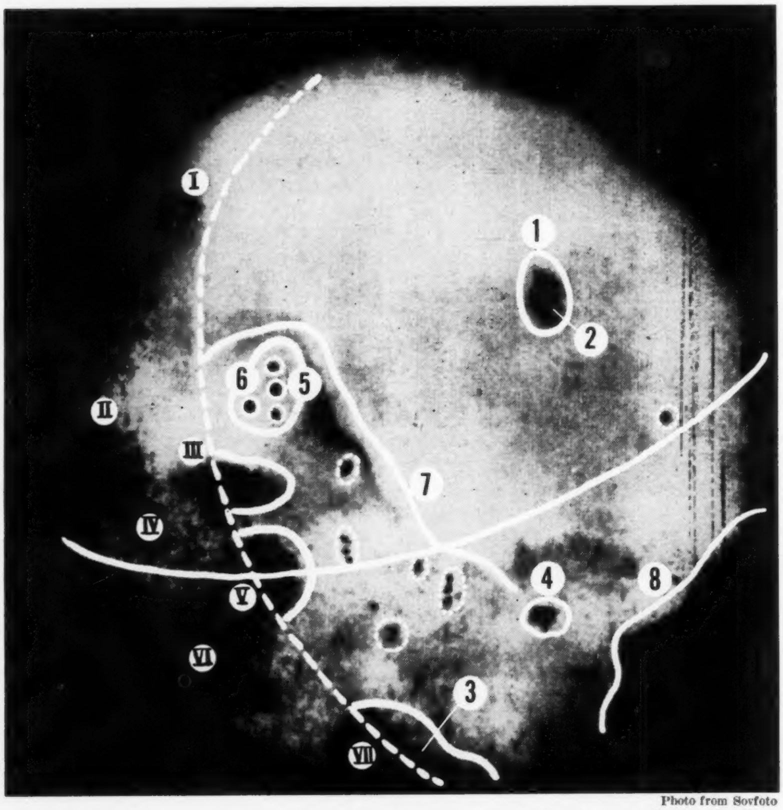


Photo from Sovfoto

Long broken line on Soviet moon photo separates "front" of moon from "back." Long solid line represents moon's equator. Soviets gave Russian names to following lunar features: 1—Moscow Sea, crater 187 miles wide; 2—Astronaut's Bay; 3—Southern Sea; 4—Tsiolkovsky Hill (named after father of Russian rocketry); 5—Lomonosov Hill (named after man who reformed Russian language); 6—Joliot-Curie Crater (named after late Nobel prize-winning French scientist who was a Communist); 7—Sea of Dreams. Features with Roman numerals can be seen from Earth. They are: I—Humboldt's Sea; II—Sea of Crises; III—Marginal Sea; IV—Sea of Waves; V—Smyth's Sea; VI—Sea of Fertility; and VII—Southern Sea.

Camera Steadied by Gyroscopes

Two cameras were placed aboard the rocket's instrument capsule to take both closeups and full views of the moon. As the camera-carrying capsule moved around the far side of the moon, gyroscopes stopped the capsule's spinning motion, and kept the camera lenses pointed steadily toward the moon. After the pictures had been taken, a signal from Earth put the capsule back into its slow regular spin—to distribute the sun's heat evenly.

The control signals came from a huge radio transmitting antenna somewhere in the Soviet Union. The signal to click the shutter was given when the space vehicle was 40,000 miles from the moon, on an orbit that had taken it 292,000 miles into space.

The film, which had to be shielded to protect it from cosmic radiation, was automatically developed aboard the instrument capsule immediately after the pictures were taken. The moon images on the developed 35 mm film were transmitted to Earth by radio signals (using a device similar to a newspaper wirephoto scanner) while the spinning 600-pound instrument capsule was still a quarter of a million miles away. Television pictures of the film were also transmitted.

If Soviet rocketeers photograph any more of the moon before the United States is able to do so, lunar geography may show a preponderance of Russian names. Under international tradition, a discoverer bestows the name of his choice upon his discovery.

Scientists all over the world described the Soviet achievement as remarkable.

Power from the Moon

The moon's gravitational attraction may soon be harnessed by engineers to generate electric power on Earth. Plans are being made to dam up the tidal flows caused by the moon's (and the sun's) gravitational pull on the oceans, and to use the trapped waters to generate electricity. The dams would capture water at high tide, and release it at low tide through turbine generators.

Engineers have long kept an eye on Passamaquoddy Bay, located between Maine and the Canadian province of New Brunswick, as an ideal site for such a project. Passamaquoddy Bay is an arm of the Bay of Fundy, which has the greatest tidal variations in the world, amounting to 70 feet at times. As long as 40 years ago, engineers realized that such a change in water level represented a tremendous amount of energy—if it could be harnessed.

Plans for constructing dams and powerhouses around Passamaquoddy Bay have recently been pronounced as practical by an international board of American and Canadian engineers.

Such a tidal power station would achieve the first conversion of the moon's gravitation and motion into power available on the surface of the Earth. It would allow mankind to use a third major source of fundamental energy, separate and independent from nuclear energy or solar radiation.

Pull of the Moon and Motion

The energy in the tidal changes actually comes from the gravitational pull of the moon and the combined motions of the Earth and moon. The moon pulls the oceans into an elliptical shape with two bulges—one on the side of the Earth facing the moon, the other on the opposite side of the Earth. As the Earth turns on its axis, these bulges stay pointed at the moon, resulting in two tidal waves running along the oceans (*see drawings at right*).

The sun also pulls on the oceans, but with only half the force of the moon, because the sun is farther from the Earth. When the sun and moon pull in the same direction, unusually high tides result.

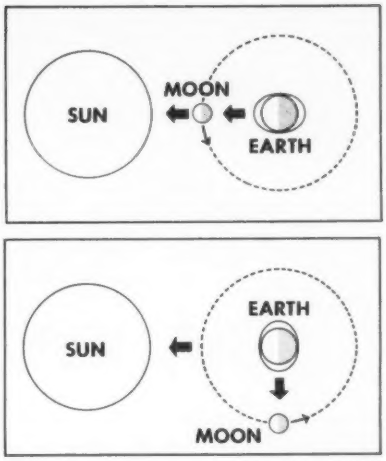
The average tide actually found in the open ocean is only two and a half feet. However, when a tidal bulge approaches a continent, it may rise much higher, depending upon the shape of the shoreline and the "shelf" on the continent. Tides in the Bay of Fundy (funnel-like in shape) reach the 70-foot mark under favorable conditions.

The Passamaquoddy power project is expected to draw an average annual energy of 1,143,000,000 kilowatt hours from these unusually large tidal flows. Another tidal power station planned for the estuary of the River Rance, in France, will produce about 800,000,000 kilowatt hours a year. This represents only a fraction of the total energy available from the tides.

All tidal power stations face one big drawback—they can generate electricity only when the tides are flowing in or out. For about twelve out of every 24 hours, when the tide is low, the tidal turbines would be silent. Since we could not regulate our consumption of electricity according to the six-hour changes of tide, such intermittent operation would not be practical.

Both the Passamaquoddy and Rance project plan to solve this problem by building a standard (non-tidal) hydroelectric dam and power station farther upriver. This dam would provide auxiliary power when the tidal generators were stopped. When the tidal station was running, the auxiliary hydrostation would be shut down, allowing water to accumulate in the reservoir.

The big advantage of tidal power stations is that come what may, drought or fuel shortage, the moon will always be there to create tides and operate the generators.



Science World graphic

Strong spring tide is caused by moon and sun pulling together. They pull water away from Earth on near side and pull Earth away from water on far side. When moon and sun pull at right angles, sun's pull partly cancels pull of the moon.

Deep Freeze Blood

A new technique for storing whole blood is being developed by the Linde Company, a division of Union Carbide Corp. This technique, which enables blood to be stored for prolonged periods, may eventually revolutionize our present techniques for storing blood.

Indefinite storage of blood on a large scale requires a method which will alter the composition of blood as little as possible.

Quick freezing to −320 degrees F. (−196 degrees C.) with liquid nitrogen enables blood to be stored indefinitely with maximum recovery of the red blood cells. One pint of blood can be frozen in less than 45 seconds.

From all the evidence so far, no significant damage to blood occurs when it is stored at the −320 degree F. temperature of liquid nitrogen.

Why is there an urgent need for stored whole blood? At present, whole blood stored at ordinary refrigerator temperatures can be used for transfusions up to a period of 21 days. After this time, whole blood can be processed to yield plasma or plasma components, but it can't be used for transfusions.

The primary aim of a blood bank is to preserve the red cells. The red blood cells make up 45 per cent of whole blood's volume. They have been described as chemical envelopes which contain the red, oxygen-carrying protein called hemoglobin.

The life span of red blood cells is only 120 days in the human body. The red blood cell does not have a nucleus. A cell without a nucleus can neither divide nor multiply, for cell survival

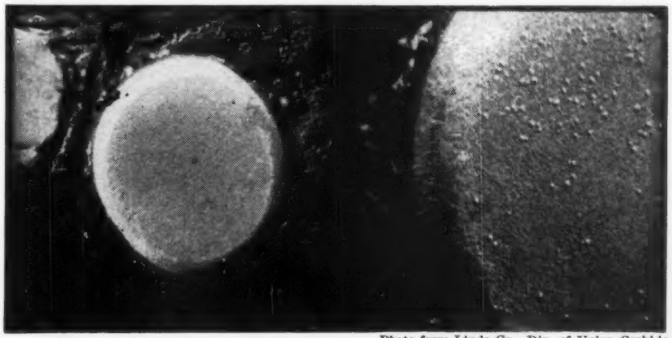


Photo from Linde Co., Div. of Union Carbide

Photomicrographs of red blood cell above were made with an electron microscope. Cell was frozen with liquid nitrogen. Photo at left shows cell magnified 4,600 times. At the right the same blood cell is shown as magnified 17,400 times.

Science in the news

and reproduction require a nucleus. Red blood cells are formed *only* in the red bone marrow.

In practice, the maximum period for the preservation of red blood cells is less than 120 days. The National Research Council has standardized the dating period for blood. This is the time in which a blood transfusion will result in the survival of at least two thirds of the transfused red cells for 24 hours.

The 21-day storage period is adequate for the most frequently used blood groups and types. But it is not adequate for rare blood types. Imagine bottles of rare blood types sitting on a refrigerator shelf for three weeks, and then having to be salvaged as plasma—only to be in urgent need a week later.

When scientists achieve indefinite storage of whole blood we will be able to preserve rare blood types in large quantities to meet all emergencies. One of the fastest growing needs for whole blood is in major surgery—especially in heart operations, where up to 20 pints of blood may be required.

Temperature fluctuations from storage temperature to close to 0 degrees C. (at which water freezes) can be destructive to blood and its components—such as plasma. This destruction is due largely to the formation of crystals.

When whole blood is stored at −320 degrees F. a fascinating physical phenomenon occurs. At this low temperature there is not enough heat energy to support chemical or physical change. Crystal structures such as ice cannot form or grow. At temperatures of zero or −50 or −100 degrees F., crystals form and grow. The ice in your refrigerator has crystals in it that are constantly growing in size.

Scientists are faced with the problem of finding a fast freezing method that halts the growth of crystals before they get large enough to damage the live blood cells. Crystals forming in or around the red blood cells cause the cell walls to become porous. When this happens, the cells begin to leak hemoglobin, which supplies all body cells with oxygen.

The speed at which the freezing takes place is important also for another reason: As the water in the cells congeals, the normal salt solutions become more and more concentrated. Too strong a concentration of salt may kill the cells. Therefore, the freezing must be done very quickly.

Liquid nitrogen is used as the refrigerant in the Linde process. It has the ability to fast-freeze at very low temperatures and is convenient and economical in use.

The research now completed indicates that by 1962 we may have a practical way of preserving blood for long periods of time.

Until that time arrives, remember that *today* voluntary contributions of blood are constantly needed by hospital, community and Red Cross Blood Centers. This is the only way we *now* have of insuring a blood supply for all emergencies. Continue to give blood not only when needed, but throughout the year.

Virus Fights Germs

The dread staphylococcus organism may have met its match in a virus harmless to man. The virus is a bacteriophage—it attacks one germ type only. That type is the staphylococcus organism, which so far has fought off every drug used to combat it.

Dr. William R. Muir, an assistant instructor of surgery at the University of Pennsylvania, began growing anti-"staph" virus which he obtained from a patient's infection. The virus was put to the test, first in test tubes, then in experimental mice. The virus did not destroy all the infections at the strengths tried, but it reduced the "staple" organisms to a great extent.

Dr. Muir reported that "we don't expect that virus injections will rid a patient of an infection entirely on its own." But the virus may destroy enough organisms to allow the body's defense mechanisms to finish the job.

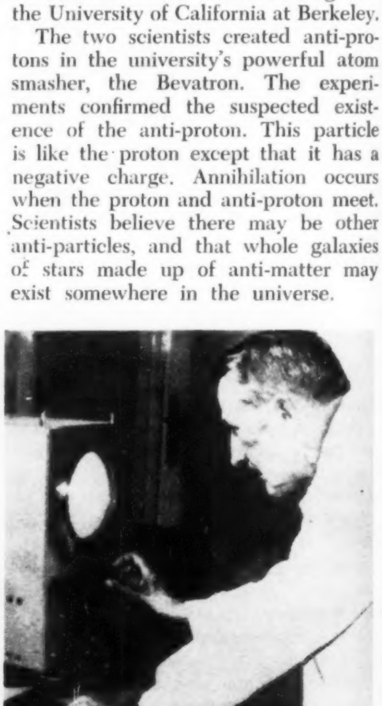
Nobel Physics Prize

Identification of the anti-proton brought the 1959 Nobel Prize in physics to two U. S. physicists, Dr. Owen Chamberlain and Dr. Emilio Segre of the University of California at Berkeley.

The two scientists created anti-protons in the university's powerful atom smasher, the Bevatron. The experiments confirmed the suspected existence of the anti-proton. This particle is like the proton except that it has a negative charge. Annihilation occurs when the proton and anti-proton meet. Scientists believe there may be other anti-particles, and that whole galaxies of stars made up of anti-matter may exist somewhere in the universe.

Wide World photo

Dr. Owen Chamberlain *(left)* and Dr. Emilio Segre, both of University of California (Berkeley), won Nobel physics prize for confirming existence of anti-proton.



Wide World photo

Dr. Jaroslaw Heyrovsky, Nobel Prize winner in chemistry, discovered polarography —electrical method of chemical analysis which measures properties of ions and can detect traces of metals in solution.

Space Ideas

Ideas for advancing our position in the space race are pouring in from Americans in all walks of life, a National Aeronautics and Space Administration official reports. And somebody could win $100,000 as a reward for a topnotch technical suggestion.

Under the law, NASA's administrator can recommend a cash award up to $100,000 for an outstanding contribution to aeronautical or space activities. The Board has processed about 1,200 ideas since December, but no award has yet been made.

Dr. James A. Hootman, secretary of NASA's Inventions and Contributions Board, said many suggestions are from high school students.

An oft-submitted idea is for launching a space craft from a mineshaft, sunken tube or inclined track running up a mountain. Steam or compressed air are suggested for "getting the rocket going" before its own expensive fuel is ignited.

"Some of their plans are ingenious," Dr. Hootman said. "But more often the suggestion is for something not as good as that which we already have. In any case, we try to offer constructive answers to queries."

Ideas from high school students are "as good as those we get from the average citizen," he said, but the best ideas are from people in the field.

Wise Old Owl?

Is the wise old owl really wise? Apparently not, according to the research of Roger S. Payne, a graduate biologist at Cornell University. Mr. Payne reports that owls "are dumber than chickens, if that's possible."

The owl is almost completely unable to learn by experience, Mr. Payne found. It will take off from a perch and crash time after time into rafters. If it cannot get around one side of a box, it does not have sense enough to try going around the other side.

Mr. Payne also found that owls are not blind in daylight, nor do they see very well at night. His tests show that an owl is guided only by sound when catching mice in the dark. Its eyes take second place to its ears.

Mr. Payne carries out his research in a room so dark that photographic negatives exposed for long periods show no evidence of light. In order that he may see what is going on, Mr. Payne uses a "snooperscope." This is a device used by World War II riflemen to find targets at night. He uses the infrared rays of the scope to follow an owl's attack on a mouse.

N. Y. Herald Tribune photo by Nat Fein

Bones of giant dinosaur were dug up by four boys in three-year Colorado project. Bones are being prepared by a team of experts at American Museum of Natural History (N. Y. C.) for shipment to Cleveland (Ohio) Museum of Natural History.

Dinosaur Students

Five years ago three Cleveland, Ohio, high school students and one college junior packed their picks and went dinosaur-hunting in Colorado. Three summer vacations later they had blasted free nearly all the bones of a giant fossil dinosaur from the rocky bank of a stream near Canon City, Colorado.

The dinosaur, officially called Haplocanthosaurus—and naturally nicknamed "Happy"—turned out to be a 70-foot monster. Only the head, the front legs, and a few other sections were missing from the "find."

The 160,000,000-year-old bones were found under 20 feet of shale and eight feet of sandstone, which had to be carefully cut and blasted away. One block of stone weighed about 6,000 pounds. Finally, the last bone was sent to the American Museum of Natural History in New York. There five experts are mounting the bones and reconstructing lost parts.

The first installment of the completed skeleton, standing more than 20 feet high, was recently sent to the Cleveland Museum of Natural History. It cost the museum about $50,000, counting the expedition.

When the students originally started out, they had no idea they would make such a significant find. "Happy" is the first of his genus ever to be mounted. Only three specimens of his kind have been discovered. The dinosaur comes from a group believed to be the ancestor of all dinosaurs, giving it great scientific importance.

The four dinosaur hunters were Wesley Williams, then 14, now a biology major at Johns Hopkins University; Edward Delfs, then 20, now a medical student at Western Reserve University in his home city; William West, Jr., then 17, now a student at Yale Law School; and Richard Jones, then 17, now employed by a Cleveland newspaper.

"We were lucky," said Delfs. "We found it only because one of the boys fell to talking with a Kansas geology student in a camp washroom."

All the boys had been musuem volunteers in Cleveland. They were to have gone on a joint expedition with experienced paleontologists of the Smithsonian Institution, Washington. At the last minute the Smithsonian group canceled its plans. The Cleveland Museum officials told the boys they could go by themselves. The truck and equipment were all ready.

"Sounds" for Birds

Piercing hawk cries, deafening machine-gun blasts, and rumbling thunder are being amplified and blared out from speakers along the famed rocket sled track at Holloman Air Force Base in New Mexico.

Amplification of the "weird sounds" is being used to scare birds from perching on the glistening rail of the sled track. The birds do not hear the approach of the sled. The vehicles travel at supersonic speeds.

When a 212-pound sled traveling at 3,000 miles per hour hits a soft little bird, it is not the bird alone that suffers. A 10-inch jagged hole was ripped completely through the one-quarter-inch steel nose cone of a sled in a recent collision with one of the perching birds.

Harvest of Algae

You can help the U. S. Government by devising an economical method for harvesting algae. No one knows how to gather it inexpensively. (Here is a problem that may contain an idea for a science project.)

Curiosity Catchers

Remember the Bouncing Ball?

The September 9 issue of *Science World* showed two Curiosity Catchers. In one the splitting and checking of a tree stump was the feature. In the other, a series of closely spaced photos caught a ball as it bounced through a series of shortening bounces.

Many people recognized the bouncing ball as an interplay between kinetic and potential energy. The conservation of energy had to be kept in mind. Similarly, the transformation of energy and energy of deformation.

These important scientific principles were reviewed and applied by students who studied the bouncing ball Curiosity Catcher. It was also an exercise in planning an experiment—one of the most valuable skills to be gained from science courses.

The problem can be stated as: How is the potential energy of a ball at the peak of a bounce gradually changed into other forms of energy as the distance of the ball's ascents and descents is gradually reduced in a series of bounces until the ball finally comes to rest?

A logical hypothesis considers the dislodging of air particles during fall, the deformation of the ball or floor on impact, the rise of temperature of the ball or floor, etc.

To attack the problem, quantitative observations are needed. How much does the ball weigh? How high is each bounce? Does the floor move and, if so, how much? How much heat might be generated if the potential energy is converted into heat energy?

Much ingenuity can go into an investigation of this Curiosity Catcher. Interesting data can be gained by comparing balls of equal mass but differing elasticity. Temperature changes are most difficult to observe. The suggestion of using a hollow rubber ball and filling it (hypodermic needle) with water has interesting possibilities.

Twenty of Sister Mary Herman's juniors and seniors at Don Bosco High School in Gilbertsville, Iowa, receive an award for their response to the Curiosity Catcher in the September 9 issue. Their response began with an attempt "to find out just what factors play a part in the bounce of a ball."

"We collected a number of balls of various volumes, densities and weights. Next we compared the bounce of these balls by dropping them at different heights, and on different surfaces.

"Some information gained in our experiments is: (a) A compact ball such as steel bounces higher and more times on a compact surface. (b) The bounce of a large air-filled ball, such as a basket ball, is high, especially on a compact surface. (c) Weight is an important item causing the balls to lose height with each bounce."

Sister Mary Herman's students included charts on which they recorded data. We are sure it would have been fun to follow "the bouncing ball" in her classroom when this Curiosity Catcher was being explored.

Science World is happy to send these students a copy of *Van Nostrand's Scientific Encyclopedia*—the book they chose for their classroom shelf.

Problem on Corrosion

Sometimes iron posts corrode much more actively at the point where they are set in cement than above or, apparently, below this point. Why? Of the various hypotheses that come to your mind, which one would you investigate first?

What kind of an experiment could you do to prove your hypothesis? If it proves wrong, would you change your hypothesis or design a new experiment?

To give you some of the fun of exercising your curiosity, *Science World* includes in each issue some Curiosity Catchers, things we hope will arouse your curiosity and spark it into planning experiments and investigations with the other members of your class.

For the science class that sends in the best plan of attack for following up each Curiosity Catcher, *Science World* will award a science reference book for the classroom shelf—a book of your choice!

Each class entry must be postmarked not later than 30 days after the date of the issue in which the Curiosity Catcher appeared. Address your entry to Curiosity Catchers, Science World, 33 West 42nd Street, New York 36, N. Y. Entries will be judged on how clearly the problem is worded, on how much additional information has been brought together, on the probable fruitfulness of hypotheses, and on the strategy with which experiments are planned or carried out.

today's scientists

Dr. Severo Ochoa
Dr. Arthur Kornberg
Biological Architects

Severo Ochoa.

Wide World photo

Dr. Ochoa made RNA in a test tube.

UPI photo

Dr. Kornberg made DNA molecule.

"ARTHUR, are you going through the ordeal I am?"

"Not yet," answered the voice at the other end of the telephone line." It's too early." It was 1 p.m. in New York City, but only 10 a.m. in California.

Dr. Severo Ochoa (Say VAY ro O CHO ah), chairman of the Department of Biochemistry at New York University College of Medicine, put down the telephone receiver. Amid popping flashbulbs and grinding cameras he smilingly announced to reporters, "he (Arthur) sounded very happy."

Arthur was Dr. Arthur Kornberg, professor of biochemistry at Stanford University in California. The telephone conversation that had just ended was no ordinary one, but neither were the participants. These two men had suddenly been catapulted into the public eye because they had won the coveted Nobel Prize in medicine and physiology.

Teacher and Student Share Prize

The two prize winners were more than 3,000 miles apart, but their contributions to science were very similar. Dr. Ochoa synthesized ribonucleic acid (RNA). Dr. Kornberg did the same with deoxyribonucleic acid (DNA). Both substances are nucleic acids.

Now a U. S. citizen, Spanish-born Dr. Ochoa received his medical degree with honors from the University of Madrid in 1929. In 1931 he started his career as a teacher at the same university. When he came to the United States in 1941, he was appointed an instructor and research associate in pharmacology at Washington University in St. Louis.

Next came an appointment to the post of research associate in medicine at New York University. Since 1942 he has advanced to the chairmanship of the Department of Biochemistry. Honors are not new to him. Now he has been admitted to the charmed circle of the world's greatest scientists.

The two winners met for the first time in September 1946. Dr. Kornberg was then a post-graduate student under Dr. Ochoa. This month both teacher and student shared a Nobel Prize. He was "an exceptional student" who had "an extremely brilliant and rapid mind. I am very proud of him. I can say he was my best student," Professor Ochoa commented.

"Marked for brilliance," said Dr. Kornberg's associates at the University of Rochester, where he received his M.D. degree in 1941. How right they were! Dr. Kornberg, now 41 years old, was graduated with a B.S. degree from the City College of New York in 1937. In 1942 he joined the National Institutes of Health of the U. S. Public Health Service. There he advanced to the post of medical director. In 1947 he went to Washington University in St. Louis.

When Dr. Kornberg moved to Stanford University in California he switched his loyalty from the St. Louis Cardinals to the San Francisco Giants. His three sons are still Redbird fans.

How do Nobel Prize scientists work? If you were to interview Dr. Ochoa at NYU's College of Medicine, he would probably first show you a view of the East River. Next would come a tour of his laboratory. Such is Dr. Ochoa's way. His interests are many. He relaxes with the music of Beethoven and Bach. His hobby is outdoor color photography. He has been described as demanding and exacting when at work, but his ever-present sense of humor helps to lessen the tension under which he and his colleagues work.

Dr. Kornberg's work habits are similar. He has the knack of getting his associates to work at his own level of intenseness and devotion. Highly competent in solving technical problems, he is capable of long hours of concentration. Both scientists worked independently on their research.

Building Blocks of Life

For a better understanding of the significance of their discoveries, let's first unravel the story of nucleic acids.

Proteins have been called the "building blocks of life." Nucleic acids (DNA and RNA) are the "blueprint" that determines the structure of the building blocks. These acids are found in living tissues. DNA is found inside the chromosomes in the nucleus of the cell, RNA in the cytoplasm outside the nucleus. Scientists believe that the nucleic acids may hold the key to the hereditary structure of all plants and animals.

Both DNA and RNA are in the shape of long chains. X-ray analysis of DNA reveals it to be a double molecule. Chains made up of phosphate and sugar molecules are twined around

each other in the shape of a spiral staircase or helix. Units of four molecules—thymine, cytosine, adenine, and guanine, which are nitrogenous bases—are arranged in shelf-like layers inside the helical chains. (In the drawing on this page the bases are represented by shaded circles linked to each other.) The phosphate and sugar molecules spiral around these bases.

The bases, linked in pairs, may be arranged in a variety of ways. This arrangement enables molecules of DNA to react with the elements in the fluids circulating through the cell. If conditions are right and the essential materials are present, the molecules will, in effect, duplicate themselves. The arrangement of bases on one chain determines the arrangement on the other chain.

DNA—Master Mold

Scientists are looking forward to more information on how RNA behaves inside the living cell. Then they will be able to explain the events that occur in the cell and the circumstances under which they take place.

DNA is the material in genes which determines the physical and mental characteristics of all living things. Genes govern inheritance from one generation to another. They also govern the development of specific characteristics in an individual, such as color of eyes and hair. They are found inside the chromosomes of living cells. Each chromosome has a specific amount of DNA which never varies.

There is direct evidence that DNA has a genetic role. Thus, if pure DNA is extracted from certain bacteria, it is capable of transferring some of the properties of the strain to a related strain. Scientists have found that when a bacterial virus infects a bacterium, the DNA of the virus and *not* its protein enters the bacterial cell. Progeny virus produced in the cell have much of this DNA.

How does DNA reproduce itself? Dr. F. H. C. Crick of the University of Cambridge believes that the two chains of DNA, which fit together as a hand fits into a glove, come apart. The hand then acts as a mold for formation of a new glove and the glove acts as a mold for a new hand. Thus there are two gloved hands where there was only one before.

From the few facts scientists have been able to gather concerning the nucleic acids, they have developed this theory:

The nucleic acids control the making of each organism's characteristic living substances—its proteins. What role do DNA and RNA play in determining the make-up of the whole organism? It is believed that DNA is the master mold for passing heredity patterns from generation to generation. RNA serves as the copy used in the actual manufacture of proteins. This theory has served researchers as a guide in working out the intricacies of biological systems.

Dr. Kornberg's research uncovered an enzyme in common intestinal bacteria identified as escherichia coli. (An enzyme is an organic catalyst that speeds up a chemical reaction.) This enzyme promotes the manufacture of

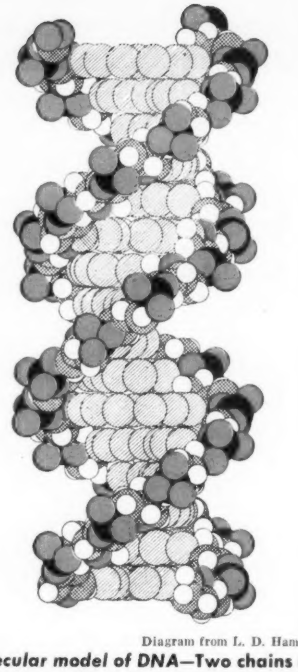


Diagram from L. D. Hamilton

Molecular model of DNA—Two chains are wound together in shape of double helix. Helical chains are complementary.

DNA from smaller organic molecules.

Dr. Ochoa uncovered an enzyme in the bacteria known as acetobacter vinelandii. This enzyme turns alcohol to vinegar. These newly found enzymes were used to make compounds almost identical with DNA and RNA.

The test tube models of DNA and RNA resemble the real nucleic acids both physically and chemically.

What is the significance of this discovery? The Caroline Institute, which makes the annual Nobel Prize nominations for physiology and medicine in Stockholm, said that the two biochemists "clarified many of the problems of regeneration and continuity of life."

New Insights

The work of the two Nobel Prize winners, as is so often true of "pure" research, will undoubtedly have practical value. Their work may help solve the riddle of cancer. In cancer we have abnormal growth and reproduction of cells. The research of the Nobel Prize winners may also give scientists new insights into the nature of viruses and their reproduction.

How does Dr. Ochoa feel about his Nobel prize? "I think it is a very great honor, something very good to happen to a scientist. I do not believe that a scientist seeks or needs compensation—he gets his compensation from his work—but if there be other compensation, this would be it."

Indeed it is!

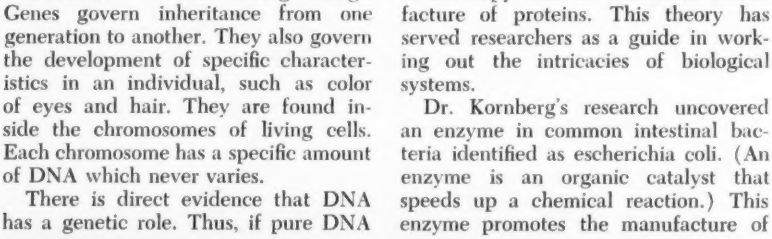


Photo from Cecil E. Hall, MIT

Like bits of cord—DNA molecules enlarged 100,000 times in electron micrograph.

tomorrow's scientists

Project: Experiment in Spawning of Tropical Fish

Student: **David deHoll**
Heelan High School
Sioux City, Iowa
Science Achievement Awards Winner
Teacher: **Sister Mary Cecilia, O.S.F.**

[Interested in tropical fish? David deHoll has been fascinated by ichthyology since the seventh grade. He began by collecting fish on his vacations. Slowly his collection increased. His biology teacher suggested that he enter the Indiana State Science Fair with a collection of small, rare fish that were found in Indiana streams. Now, he was really enthusiastic. David associated with members of an Aquarium Society and gained much valuable information from them. His curiosity aroused, he began a project which eventually won a Future Scientists of America Foundation award.

If you are interested in tropical fish, you will want to continue David's work with fish where he left off. Devise your own improvements or variations, or develop your own science project and enter it in the science fair or the Future Scientists of America Foundation awards program.]

As my knowledge of tropical fish increased I became especially interested in one particular species of fish—Pterophyllum eimekei.

Pterophyllum eimekei is in the Cichlidae (pronounced SICK lidee) family, which is a group of spiny-rayed fish resembling the Ponacentrids in having only one nostril on each side of the snout, instead of the usual two. Its genus, Pterophyllum (TER o-fill lum), is a small one consisting of only three species. Pterophyllum means winged leaf, which is an adequate description of this remarkable fish.

Eimekei is one of the three species of this genus. It differs from the other two species (*scalare* and *altum*) in its number of soft and hard fin rays in the dorsal and anal fins. The differences are not very pronounced; a casual observer would never notice them.

Pterophyllum eimekei inhabits many areas of South America. The main spawning area is, however, the Tapajoz River, a tributary of the mighty Amazon. The Tapajoz River abounds with many other fish, especially Cichlisoma festivum. Pterophyllum eimekei is a very shy, nervous fish. It seldom ventures from the thickly planted river banks that form its spawning ground. When it does, it follows the festivum, which is a larger, more brazen fish of the same general family.

Spawning of Eimekei

The first problem encountered in spawning this fish is actually procuring a mated pair. Pterophyllum (commonly known as angel fish) and most of the family Cichlidae choose their own mates.

The Pterophyllum choose their mates on the merits of physical strength. Often before the fish actually mate they will lock jaws and perform a physical struggle. This is usually a good sign that the fish will eventually mate. However, if one of the pair happens to lose its nerve and flees from this tussle, it is certain death. Fear is fatal; the stronger mate will then pursue and kill the other.

There are two ways of obtaining a mated pair of Pterophyllum eimekei. One is to buy a mated pair; the other is to produce your own. The former is impractical, not only because the price is so prohibitive, but also because there is no guarantee that the fish will continue to spawn. The change in water conditions and other factors may cause the pair to separate. Angel fish mate for life, and if they break up they will not remate except in very, very rare cases.

I have witnessed such a case. It occurred when a pair fought continually and finally separated. In order to prevent the larger of the two from killing its former mate I placed another Pterophyllum eimekei (a "Federal mediator") of about the same size and age with them. The larger of the former pair and the new entry mated and spawned.

Purchasing a mated pair does not give a fraction of the feeling of accomplishment that producing your own pair of Pterophyllum eimekei does.

I obtained nine Pterophyllum eimekei in November 1957. These fish were approximately nine months old. I obtained them from a fellow aquarist in Omaha, Nebraska. I placed them in a 65-gallon aquarium. This gave them more than enough room. They were kept at a temperature of 76 degrees F., and they were fed a high protein diet which would help them to grow to the six-inch size that would be necessary if they were to have a successful spawning. This meant that the fish would have to grow more than four and one-half inches.

The food consisted of prepared and live food. The prepared food was a

David with part of his aquarium project. He now attends the U.S. Naval Academy.

Photo shows portion of offspring from the October 12, 1958, spawning. Shadows from floating plant life give illusion of black pigmentation to some of fish.

variation of the famous Gordon's formula. It consisted of one pound of calf liver (finely screened), a varying amount of creamed spinach, pablum, and wheat germ. It was cooked and frozen. It was then thawed for feeding.

The live food consisted primarily of Daphnia pulex, Enchytraeus albidus, and artificially hatched Arteria salina. It was fed in various quantities, depending upon the digestive effects that the particular food had upon the fish. (Daphnia pulex has a decided laxative effect upon the digestive system of a fish. Enchytraeus albidus has the opposite effect.) Arteria salina is considered to be a nearly nutritionally perfect food.

On this diet the fish grew rather rapidly for this particular species. Full maturity normally takes about two years. I cut this period down to eighteen months.

Difficulties Encountered

The diet solved the first problem, that of obtaining fish of the proper size. There were, unfortunately, other problems encountered in the spawning of Pterophyllum eimekei.

One of the biggest problems was getting the proper water conditions for the fish. If I was to succeed I necessarily had to consider what the Pterophyllum eimekei experiences in the way of water conditions in its natural habitat. Most rivers of South America have water that is soft and acid. After doing a sizable amount of research on the water conditions in South America, I discovered that the water of the Tapajoz River is also soft and acid. The hardness depends upon the season. In the dry season the hardness remains about 119.7 parts per million (magnesium and calcium compounds), but in the rainy season, the normal spawning season, the hardness averages about five degrees, or about 85.15 parts per million (p.p.m.). This river averages between 6.5 to 6.8 pH (slight acidity).

I set out to change the Sioux City water to resemble that of Pterophyllum eimekei's natural environment. The most difficult task was to reduce the hardness that is encountered in Sioux City water. The water averages about 38 degrees of hardness (DH), but occasionally it exceeds 42 DH. To reduce DH quantity from 42 to 5 is an exceedingly difficult task.

Most homes in Sioux City are equipped with water softeners containing resin crystals which make use of the ion exchange process. These large water softeners are constructed so that they are capable of handling a large volume of water. This is fine for average usage, but for an experiment such as mine the water that comes from the water softeners is still much too hard. These softeners usually soften the water to about 20 DH.

To soften the aquarium water further, large outside filters were incorporated. They were powered by small air compressors and were loaded with another type of resin. I used an acrylic type of resin, known as "amber light" in the drug industry, which was obtained through the courtesy of Eli Lilly and Company, Indianapolis, Indiana. It is not on the open market, but in experimentation I have found it highly satisfactory.

In the very bottom of the filter, above the layer of spun glass, I placed a five-inch layer of amber light. On top of this layer of amber light was another layer of glass wool. Above this was a two-inch layer of activated carbon, which I used to remove any injurious gases from the aquarium water. Above this was another layer of glass wool, which filtered the large dirt particles from the water. Water flowed in at the top, and was filtered in glass wool. It was purified in carbon and softened by the resin. Then it was carried back into the tank by means of an air lift connected to an air compressor.

The amber light was regenerated by means of a strong solution of salt or a weak basic solution. By this process I succeeded in rendering the water returning to the tank soft and very slightly alkaline to neutral. In fact it had been lowered to 3 DH. After a week's time the dissolved mineral from the aquarium gravel had brought it to the optimum value of 5 DH.

Next I proceeded to change the pH. Sioux City water is very alkaline. A reading of 8.2 pH is not uncommon. For the chemist this is usual, but to a fish this is most unsatisfactory. I decided to use a method that is still in the experimental stage, instead of the methods normally used. The usual methods, generally the addition of some type of acid, are slightly dangerous to the fish.

I decided to use German peat as my softening agent. I used the same filter except that I replaced the amber light with a thick layer of German peat. German peat is highly acid. It is organic and is similar to substances that are found in most acid streams. I filtered the water through this bed of German peat and returned it to the tank with the proper degree of acidity. The water took on a taint of amber stain which was attractive. Also, I believe that German peat was very beneficial to the fish.

[*Editor:* Here's an idea for a science project: "German Peat: Beneficial or Harmful to Fish."]

Preparations for Spawnings

At this time I noted that the fish seemed to be ready to begin mating. I paid special attention to two of the three fish which had grown to a slightly larger size.

On July 31 this pair spawned for the first time. They laid their eggs upon a strip of slate three inches wide and twelve inches long. The next morning the eggs were gone. I was not disappointed, however; it was to be expected. The other fish had undoubtedly excited the pair, which then ate the eggs. This is another pecularity of the Cichlidae. They will fight fiercely to protect their young against any predators, but losing a fight they will eat the eggs or young.

I then prepared a 20-gallon aquarium for the pair. It had the same water conditions as the 65-gallon tank. I planted it with Vallisneria spiralis, Crypotocorne cordata and Echinordus rangeri.

This vegetation kept these normally nervous, but now extremely high strung fish from injuring themselves. I was going to take no chances. Once before, upon transferring a pair of angel fish from their home to their breeding tank, they became so highly nervous that the male leaped from the aquarium. He died on the cement floor. The female smashed her head against the aquarium wall. She never recovered from the injury.

As an added protection I covered the front of the aquarium with a restful green paper in order to keep the fish from being disturbed by the frequent visits of my family and friends who ventured into the basement to view my project.

At each end of the aquarium I placed a 3 x 12-inch piece of slate. The temperature was increased to 82 degrees F. after the pair had been introduced into the new tank. The pair was fed only on whole frozen Artemia salina.

Pterophyllum eimekei spawn at regular intervals until they have a successful spawning. This interval can vary from one month to five days. I wish to make it clear that each particular pair has and follows a definite cycle. The pair that I had helped to mate spawned every eight days. The table below summarizes the results of the individual spawnings from August 8 to October 12.

Pterophyllum eimekei eggs just prior to spawning (72 hours) adhering to slab of sterilized slate. Eggs were taken from tank to prevent fungus growths on them.

In the first three spawnings the eggs were left with the parents. In the next series of spawnings the eggs were removed to a separate five-gallon hatching container. I did this to combat consumption and fungus growth on the eggs. I believed that it was the fungus that caused the nervousness.

Solution to Fungus Problems

Upon later examination under a microscope the fungus that seemed to be causing all the trouble was identified. It was unofficially identified as a variety of Saprolegnia. This fungus will generally yield to light doses of the wonder drugs, but this particular species seemed to have built up a specific immunity. It was at this time that I realized that if the eggs were left with the parents with an addition of Terramycin I would easily solve the fungus problem. The oxygenating and cleaning duties of the parents upon the eggs and the Terramycin stopped the fungus.

The addition of 50 milligrams of Terramycin to the water in the parent tank made a tremendous difference. The subsequent spawnings were successful. At the last count 85 per cent of the eggs hatched and became free-swimming.

There was only one obstacle left in my path. This was the problem of supplying the young fish with enough proper food. The perfect food, of course, is freshly hatched Artemia salina; the problem was to prevent the eggs from

Data on Spawnings

SPAWNING DATE	REASONS FOR SUCCESS OR FAILURE	TERMINATED DATE
Aug. 8	*Failure*—nervousness and fungus on eggs caused the pair to devour the eggs.	Aug. 9
Aug. 16	*Failure*—eggs eaten due to nervousness of parents.	Aug. 19
Aug. 24	*Failure*—eaten due to nervousness just prior to hatching (three days).	Aug. 28
Sept. 2	*Failure*—fungus growth on eggs; fungus particles apparently still in the water.	Sept. 3
Sept. 10	*Failure*—eggs hatched, absorbed egg or yolk sac, and became free-swimming. After this the two drops of Methylene Blue (10% aqueous) which I had added to stop fungus had decided toxic effect upon young. They died within two days after they became free-swimming.	Sept. 20
Sept. 18	*Failure*—fifty milligrams per gallon of Aureomycin (Pfizer) in conjunction with sterilization failed to stop fungus.	Sept. 20
Sept. 26	*Failure*—25 milligrams per gallon of Terramycin (Pfizer) failed to stop fungus.	Sept. 27
Oct. 4	*Success—success,* but very slight. Three out of a possible 300 is not too good. 100 Mg Terramycin plus aeration saved the fry.	....

Chart indicates reasons individual spawnings were either a success or failure.

Female surrounded by fry (white dots).

settling in the sea water. The eggs that sink to the bottom have a very low percentage of hatch.

Producing Food for Young

My problem was to keep the eggs in constant motion in the sea water. Aeration with an air stone was not enough; there were still places in the container where the current was not sufficient to prevent the settling.

I decided that if I changed the shape of the container I might solve the problem. I tried several experimental shapes. A large plexiglass cone, 10 inches in diameter and 15 inches high, was used; a strong, fine stream of air from a compressor was introduced at the bottom. This kept the eggs in constant motion. Also, a source of light was placed near the top of the cone. Since the Artemia salina are phototropic, they were attracted to this source and there easily siphoned off, screened and fed to the young fish.

With the solution of this problem I am producing a fairly large amount of young Pterophyllum eimekei. With a little money, infinite patience, hours of work, and a tremendous amount of luck these small fish may help to finance a small part of my future education.

The successful solving of the problems encountered in this extensive project has given me a special feeling of accomplishment. Pterophyllum eimekei is one of the most difficult of all tropical fish to spawn.

Conclusion

In order to spawn them I solved problems concerning diet, water, temperature, hygiene, and finally a mechanical problem of feeding the small fish resulting from the spawning.

Although I encountered many exasperating problems the feeling of accomplishment that I gained from successfully spawning this beautiful fish is well worth any difficulties that I may have had.

Project and Club News

Project Ideas

WHERE do students get ideas for science projects?

Several years ago Science Service began a survey to answer just this question. The latest report shows that the 320 finalists at the Tenth Annual Science Fair, held in Hartford, Conn., last May, derived their ideas from many sources.

More than one out of three—35 per cent, to be exact—of the finalists said they found their "inspirations" in a magazine article, report in a scientific journal, book, research paper, or pamphlet. Some got their ideas from project lists or news articles.

More than a fourth of the projects, 28 per cent, came from the students' own experiences, curiosity, hobbies, private experimenting, observation or study. One student set off on his project because one of his classmates said it couldn't be done.

About 14 per cent of the finalists discovered a stimulating question at school. Teachers, club sponsors, science courses, and labs were responsible for turning up these ideas.

Discussion with scientists, visits to scientific laboratories, institutes, science fairs, Junior Academies of Science or science club meetings produced the basic ideas for 11 per cent of these outstanding students.

Several others thought of good project questions as the result of science programs on television, science films, slides, lectures, and demonstrations, some of which were part of the program at special College Science Days arranged for high school students. A few finalists credited parents and relatives as their idea-sparkers. One gave the credit to a brother who was a former National Science Fair finalist.

Two years ago, a student said he dreamed the idea for his excellent project while he was asleep. If your dreams are not very useful as far as science projects are concerned, and if you have a desire to try something new, ask your science club sponsor to show you the section of the Sponsor Handbook that is called "Research for Student-Scientists." Here you will find pages of ideas contributed by professional scientists. This research needs to be done and could be carried out by tomorrow's scientists.

A booklet published by Science Service, "Thousands of Science Projects" (25¢ a copy, 10 for $1.00), lists the titles of successful projects done for the Science Talent Search or the National Science Fair, and includes a number of photographs of the exhibits.

Watch for the fall announcement brochure of the annual National Science Fair. This features pictures of many of the 1959 finalists together with their projects.

Where you get your ideas is not as important as doing something with them. Remember, the National Science Fair and the Future Scientists of America Foundation awards program are right around the corner. *Now is the time for action!*

With some or all of these ideas as background, your mind should be like a firecracker waiting to be lit. When you come across the barest mention of something new and interesting in your particular field, take off on your project!

Don Alfred Thornton, 17, of Maysville (Mo.) High School displays his project at the St. Joseph, Mo., Regional Science Fair. Don showed how the tremendous potential energy of the sun could be harnessed for heating, cooling, and electricity in the home on a commercial scale. Don got his ideas from magazine articles.

Meeting the Test

What Is Your Science Achievement Score?

By THEODORE BENJAMIN

UNDOUBTEDLY, at some stage of your school career, you have taken a reading or arithmetic achievement test. Your scores on such tests are reported in so called grade equivalents rather than in per cent.

For example, let us presume that you took the test in the third month of your 7th grade. If you made a score of 7.3 this indicates that your achievement was equal to that of the average student in the group of students used to establish to-be-expected scores. On the other hand, if you achieved a score of 9.8 at that time, it would indicate that you were two and a half years ahead of your grade.

Here is a brief test you can use to determine roughly your grade equivalent in science from the number of correct responses. Circle one answer for each question. Answers are on page 31. The table below allows you to compare your score with your approximate grade equivalent.

Number Correct	Grade Equivalent
7	7
11	8
16	9
20	10
25	11
30	12

1. Rocks changed by heat and pressure are known as (a) igneous, (b) sedimentary, (c) stratified, (d) metamorphic.
2. An eclipse of the sun can occur only at the time of (a) full moon (b) last quarter (c) new moon (d) first quarter.
3. Linen is excellent for hot weather clothing because it (a) reflects light (b) wrinkles easily (c) absorbs moisture (d) is waterproof.
4. The temperature of the surface of the sun is believed to be at least (a) 500° F. (b) 1000° F. (c) 5000° F. (d) 10,000° F.
5. The offspring are produced from fertilized eggs hatched outside the body in (a) guppy (b) robin (c) cow (d) ameba.
6. From which part of a corn plant, pound for pound, can we get the greatest amount of fat? (a) root (b) stem (c) leaf (d) seed.
7. Cactus plants lose little water in hot, dry weather because they have (a) very small leaves (b) long roots (c) green stems (d) tough seeds.
8. Every cell has a (a) chloroplast (b) food vacuole (c) membrane (d) cell wall.
9. If a characteristic skips a number of generations in a family, the characteristic is probably (a) dominant (b) incompletely dominant (c) linked (d) recessive.
10. In the blood, most of the digested food is carried in the (a) fibrinogen (b) plasma (c) red cells (d) white cells.
11. Amino acids are formed by the digestion of (a) fats (b) minerals (c) proteins (d) starches.
12. The space between the ends of two adjoining neurons is called the (a) axon (b) end branch (c) cyton (d) synapse.
13. The silk of the corn is (a) a structure for warding off insects (b) useless (c) a part of the female flower (d) adventitious roots.
14. The chemical substance used to test for protein in foods is (a) sodium bicarbonate (b) Benedicts solution (c) nitric acid and ammonia (d) iodine solution.
15. Limewater is a substance used for detecting (a) carbon (b) carbon dioxide (c) acid (d) oxygen.
16. The ratio of the volumes of four grams of hydrogen to 32 grams of oxygen at standard conditions is (a) 4:1 (b) 2:1 (c) 1:2 (d) 1:8.
17. An example of a nuclear reaction is
$${}_{7}N^{14} + {}_{2}He^{4} \rightarrow {}_{1}H^{1} + X$$
X in this reaction represents
(a) ${}_{7}N^{15}$ (b) ${}_{8}O^{16}$ (c) ${}_{8}O^{17}$ (d) ${}_{8}O^{18}$
18. The action of concentrated sulphuric acid on carbohydrates is known as (a) dehydration (b) esterification (c) hydrolysis (d) oxidation.
19. The reagents used in the laboratory preparation of iodine are (a) KI and HCl (b) KCL and NaI (c) KI, MnO_2 and H_2SO_4 (d) NaI and MnO_2.
20. Aluminum resists corrosion better than iron because it (a) is light in weight (b) becomes covered with a thin layer of corroded material (c) is softer (d) forms compounds less easily.
21. An example of a carbohydrate is (a) CH_3CHO (b) C_2H_5OH (c) $C_6H_{12}O_6$ (d) HCOOH.
22. The temperature on the Fahrenheit scale which is the same as 0° centigrade is (a) –32° (b) 0° (c) 32° (d) 100°.
23. The barometer reading becomes lowered at the approach of a storm because (a) the layer of air is thinner (b) moist air is lighter than dry air (c) there is no sunshine (d) the barometer absorbs moisture.
24. The heating elements in electrical heating devices are usually made of (a) copper (b) tungsten (c) iron (d) alloys.
25. We can speed up the rate at which naturally radioactive substances give out energy by (a) heating them (b) exposing them to high pressures (c) exposing them to gamma rays (d) alloys.
26. A convex lens of four-inch focal length will produce a virtual image when the object distance is (a) 8 in. (b) 2 in. (c) 6 in. (d) 4 in.
27. Two objects seem to lose the same weight when completely submerged in water. The objects must have the same (a) specific gravity (b) volume (c) weight in air (d) weight in water.
28. A device always connected in parallel in a circuit is the (a) ammeter (b) fuse (c) switch (d) voltmeter.
29. When viewed through blue glasses the American flag appears to be (a) black and blue (b) blue and white (c) red and blue (d) red and white.
30. The wire in the primary of a step-up transformer is usually thicker than the wire in the secondary because the primary has the (a) higher current (b) higher resistance (c) higher voltage (d) lower current.

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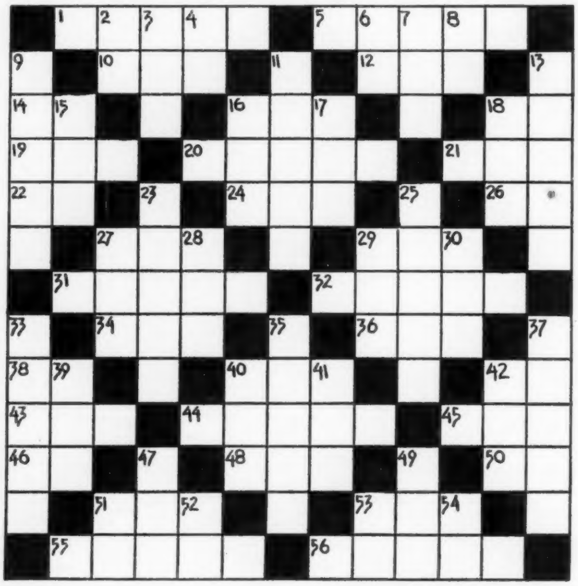
US ARMY

Matter and Motion

By James Blachowicz, Central Catholic H. S., Fort Lauderdale, Fla.

★ *Starred words refer to chemistry and physics*

Students are invited to submit original crossword puzzles for publication in *Science World*. Each puzzle should be built around one topic in science, such as astronomy, botany, geology, space, electronics, famous scientists, etc. Maximum about 50 words, of which at least 10 must be related to the theme. For each puzzle published we will pay $10. Entries must include symmetrical puzzle design, definitions, answers on separate sheets, design with answers filled in, and statement by student that the puzzle is original and his own work. Keep a copy as puzzles cannot be returned. Give name, address, school, and grade. Address Puzzle Editor, Science World, 33 West 42nd Street, New York 36, New York. Answers to this puzzle are on page 31.



ACROSS

- *1. Helium has two electrons revolving in one ________.
- *5. Discoverer of francium, Marguerite ________.
- 10. Consumed.
- 12. Mineral spring.
- *14. Silver-white semi-metal element of atomic no. 52 (*symbol*).
- 16. Female deer.
- *18. Rare earth metallic element of atomic no. 58 (*symbol*).
- 19. Paddle used to steer a small boat.
- *20. Italian physicist who directed the building of the first atomic reactor.
- *21. A state of matter having no definite volume or shape.
- 22. Mister (*abbr.*).
- 24. Greatest Common Factor (*abbr.*).
- 26. Homonym for know.
- 27. Edgar Allan Poe short story, "The ________ and the Pendulum."
- 29. Mars has ________ moons.
- *31. A gas used in electric light bulbs.
- 32. Diagram showing relationships.
- *34. Unit of resistance.
- 36. Anger, wrath.
- *38. Element of atomic no. 54 (*abbr.*).
- *40. Skilled workmanship or performance.
- *42. Metallic element harder and stronger than iron or nickel (*symbol*).
- *43. Positively or negatively charged atom.
- *44. The expanse in which all material objects are located.
- 45. 19th letter of the Greek alphabet.
- 46. *Life ____ the Mississippi* by Twain.
- 48. Three-toed Australian bird.
- *50. Radioactive, gaseous element which emits alpha particles to yield radium A (*symbol*).
- *51. Source of metal.
- 53. Distinguished Service Cross (*abbr.*).
- 55. Dispute.
- *56. Once thought to occupy all space.

DOWN

- *2. This element's radioactivity decreases about 1% in 25 years (*symbol*).
- *3. British Thermal Unit (*abbr.*).
- 4. That is (*abbr.*).
- 6. You are (*Latin*).
- *7. Measurement of revolutions (*abbr.*).
- 8. Each (*abbr.*).
- *9. All matter is made of ________.
- *11. That which causes a change in momentum.
- *13. An elementary particle whose mass is intermediate between an electron and a proton.
- 15. An organ of hearing.
- 16. Degree (*abbr.*).
- *17. Electromotive Force (*abbr.*).
- 18. Able to.
- *23. Radiant energy which enables us to see.
- *25. A class of stars of great density and relatively small mass.
- 27. Professional athlete (*abbr.*).
- 28. A male cat.
- 29. Prefix meaning three.
- 30. Open (*poetic form*).
- *33. The statement that the whole is greater than its parts is an ________.
- *35. Units of mass or force.
- *37. Effect caused by pneumatic vibration.
- 39. Immeasurable or indefinite period of time.
- 40. Imitate, mimic.
- 41. Texas Christian University (*abbr.*).
- 42. Motor vehicle.
- *47. One ________ equals the work done by one dyne acting through a distance of one centimeter.
- *49. Solid residue left after combustible material is burned.
- 51. Homonym of ore.
- *52. Element of atomic no. 63 (*symbol*).
- 53. Delirium Tremens (*abbr.*).
- 54. Civil Engineer (*abbr.*).

Science Bookshelf

90° SOUTH: The Story of the American South Pole Conquest, by Paul Siple (Putnam's, 1959, 384 pp., $5.75.)

Few men know the Antarctic better than Paul Siple, who went there first as a boy scout with the first Byrd expedition of 1928-30, and has returned five times.

Siple was one of the Americans gathered around a thermograph as the temperature fell to a new official record. The reading was minus 102.1 degrees F. The date was September 18, 1957. The place was the South Pole.

This is the exciting story of the 24 U. S. Navy Seabees under whose skilled hands a tiny community of eight polar huts arose, and of the 18 American scientists and Navy men who spent a year in the land that Captain Robert F. Scott, the English explorer, described in his 1912 diary as "an awful place."

But beyond the scientific story, this book is a saga of adventure in a strange land contemptuous alike of man and his machines, a land where arctic diesel oil turns to tallow, where machines and instruments fail as lubricants congeal, where storms and magnetic interference make navigation all but impossible. But these men conquered the savage land. How they did it is one of the great sagas of exploration.

UNDERSTANDING CHEMISTRY, by Lawrence P. Lessing (Interscience Publishers, 1959, 192 pp., $3.50; Paperbound edition, New American Library, 50¢. released simultaneously.)

Written by a science editor and author, this informative volume is a reference work for those who want a concise summary of chemistry's basic laws, and who wish to know more about recent achievements in chemistry, and the dramatic applications to which fundamental research is being put.

THE UNITY OF THE UNIVERSE, by D. W. Sciama (Doubleday, 1959, 228 pp., $3.95.)

Cosmology, the science of the universe and its creation, has jestingly been referred to as the "science of unanswered questions." In this book, one of Britain's young scientists has written a survey of cosmology for the layman. A major theme concerns the question: Are some features of the universe accidental, or can they all be accounted for in theoretical terms?

Line drawings and photos help to clarify some of the more difficult concepts.

LAVINIA DOBLER

Brainteasers

A Bull's-Eye

At a shooting gallery, the customers are permitted to take any number of shots without paying for them—on one condition: the total score for the shots must be an even 100. The target has five zones. They count 16, 17, 23, 24, and 39 respectively, with the 39, of course, being the bull's-eye. How many shots must you take in order to get your target practice at the expense of the proprietor?

Coin Count

If you had as many again, half as many again, and two and a half, you would have 20 coins. How many do you have?

[Do you have a favorite brainteaser that you would like to share with other readers? Send the brainteaser, together with the solution, to *Science World*. We will pay $5 for each brainteaser published.]

Answers to Brainteasers

A Bull's-Eye—To get your shooting for nothing you must shoot near the edges of the target, and not get near the bull's-eye with any of your shots. You must hit the target six times, and no more. You must score two 16's and four 17's. This will give you a total score of 100, and is the only combination that will. Any other combination of the numbers on the target will leave you paying for your shots.

Coin Count—Seven coins.

Answers to Meeting the Test

(See page 28)

1. d; 2. c; 3. c; 4. c; 5. b; 6. d; 7. a; 8. c; 9 d; 10. c; 11. c; 12. d; 13. c; 14. c; 15. b; 16. b; 17. c; 18. a; 19. c; 20. b; 21. c; 22. c; 23. b; 24. d; 25. d; 26. b; 27. b; 28. d; 29. a; 30. a.

Answer to Crossword Puzzle

(See page 30)

■	O	R	B	I	T	■	P	E	R	E	Y	■
A	■	A	T	E	■	F	■	S	P	A	■	M
T	E	■	U	■	D	O	E	■	M	■	C	E
O	A	R	■	F	E	R	M	I	■	G	A	S
M	R	■	L	■	G	C	F	■	D	■	N	O
S	■	P	I	T	■	E	■	T	W	O	■	N
■	A	R	G	O	N	■	G	R	A	P	H	■
A	■	O	H	M	■	G	■	I	R	E	■	S
X	E	■	T	■	A	R	T	■	F	■	C	O
I	O	N	■	S	P	A	C	E	■	T	A	U
O	N	■	E	■	E	M	U	■	A	■	R	N
M	■	O	R	E	■	S	■	D	S	C	■	D
■	A	R	G	U	E	■	E	T	H	E	R	■

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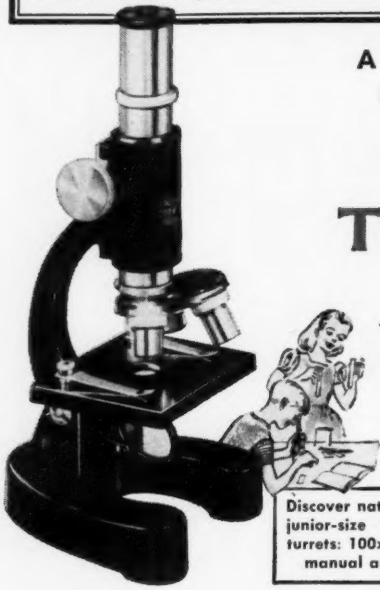

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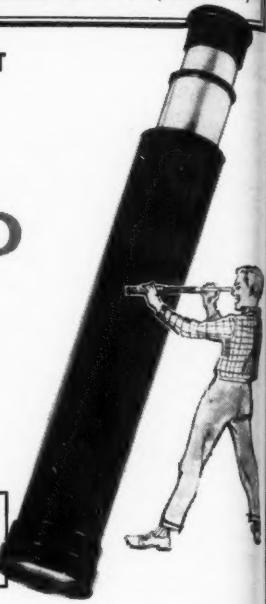

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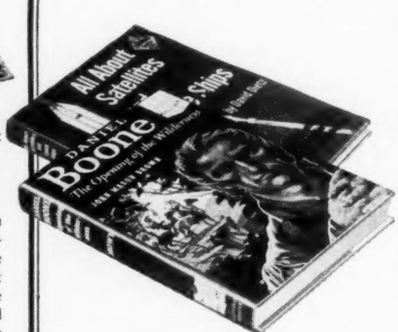

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YR-31

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